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INSTITUTE OF THE AERONAUTICAL SCIENCES

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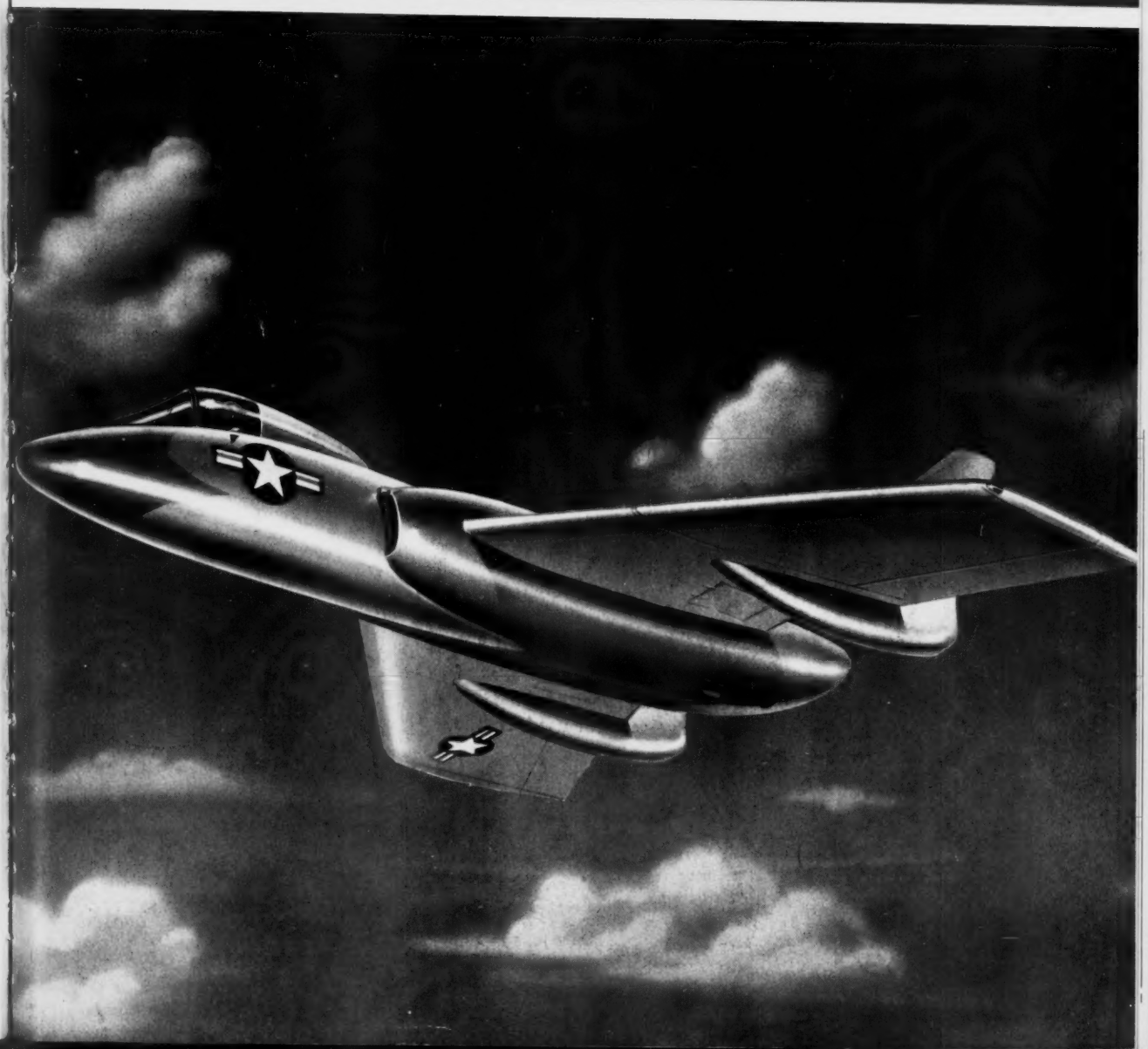
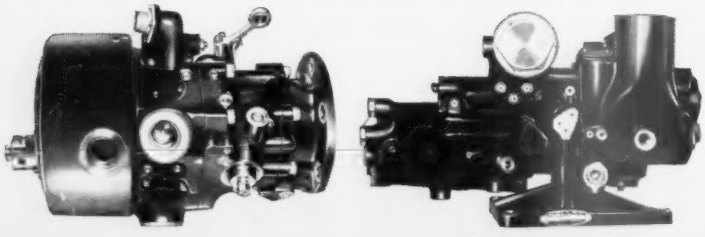


Within Seconds After Warning . . .

the Lockheed Starfire is in the air and on its way to altitudes of more than 45,000 feet. Holley designed and manufactured the turbine fuel control and the afterburner fuel control used on the F-94C's Pratt & Whitney J-48 Jet Engine.



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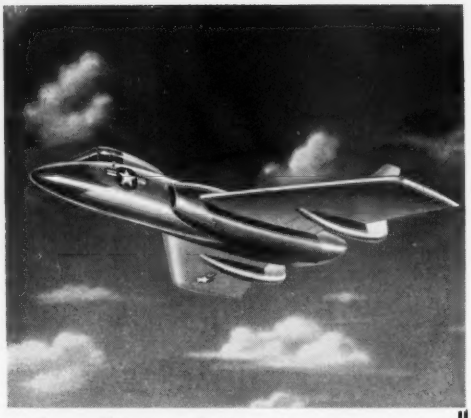

Cover—This reproduction shows the attack version of the twin-jet F7U-3 Cutlass, now being produced as a fighter airplane by Chance Vought Aircraft Division of United Aircraft Corporation. The Navy announced recently that a letter of intent had been received by Chance Vought for an undisclosed number of this attack version, designated the A2U. The A2U and F7U-3 will probably operate side by side.

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AERONAUTICAL ENGINEERING REVIEW

Vol. 12 JULY, 1953 No. 7

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I.A.S. News Notes

July 1953

AMERICAN I.A.S. MEMBERS TO RECEIVE GIFT BOOK

A complimentary copy of Eaton Manufacturing Company's latest aviation chronicle is being mailed out by the Institute this month to all American- and Canadian-residing members in good standing as of June 1. Entitled, "Fifty Years of Flight," this commemorative volume includes all of the items published in Eaton's original 1947 Aviation Chronicle and subsequent Supplements, plus much new and up-to-date material.

As in the past, Eaton, an I.A.S. corporate member company, has provided the Institute with sufficient books to supply one to each American and Canadian who is a member at the time of publication. The elaborate nature and cost of the present book precludes a wider free distribution or the replacement of lost copies. Members are urged to be on the lookout for their individual copies in the mails, and to write their names in the place provided on the bookmark inside the cover.

Additional copies of "Fifty Years of Flight" will be available through the Institute's Publications Department after August 1, at $5.00 each.

****

I.A.S. FOUNDER HONORED

Major Lester D. Gardner was presented with the American Legion Medal of Merit on June 3, for "his many years in actively aiding in the development of aviation, especially his founding of The Institute of the Aeronautical Sciences." It was awarded by the officers and members of Air Service Post 501 and presented by Col. E. E. Aldrin at a dinner at the Lotos Club, New York. Lt. Gen. James H. Doolittle made the principal address.

****

NATIONAL MEETINGS CALENDAR

July 15-17	Annual Summer Meeting and Honors Dinner, Los Angeles, California.
Sept. 7-18	Fourth International Aeronautical Conference, London, England.
Dec. 17	Seventeenth Wright Brothers Lecture, U. S. Chamber of Commerce Building Auditorium, Washington, D.C.
Jan. 25-29	Twenty-Second Annual Meeting and Honors Night Dinner, Hotel Astor, New York City.

****

WRIGHT AIRPLANE REPLICA ROLL-OUT CEREMONIES

The replica of the original Kitty Hawk airplane, built on the West Coast for the I.A.S. by 24 cooperating companies, made its debut on June 15 in appropriate "roll-out" ceremonies at the Northrop Aeronautical Institute. More details regarding this project may be found on page 22 of this issue. A complete story on the dedication of the airplane at the Annual Summer Meeting this month, detailed pictures of its construction, etc., will be featured in a later issue of the Review.

****

NECROLOGY

Baron Amaury de La Grange, president of the Federation Aeronautique Internationale, died June 10 in Zurich, Switzerland, after a long illness. He was 65 years old.

****

TELEMETERING CONFERENCE PROCEEDINGS AVAILABLE

Papers presented at the Telemetering Conference in Chicago in May are now available in bound volume form at $1.50. Copies may be obtained through R. F. Post, Allen D. Cardwell Manufacturing Company, Plainfield, Conn.

****

CALENDAR OF SECTION MEETINGS

July 9---San Diego Section: I.A.S. Building. All-technical meeting, 7:30 p.m. "V-2 Control Systems" by Dr. Hans Friedrich, Design Specialist, Consolidated Vultee Aircraft Corp.

July 23---San Diego Section: I.A.S. Building. All-technical meeting, 7:30 p.m. "Structural Adhesives" by Seth Gunthrop, Consolidated Vultee Aircraft Corp.

Aug. 6---San Diego Section: I.A.S. Building. All-technical meeting, 7:30 p.m. "Fatigue in Aircraft Structures" by Garner Green and Roy Miller, Consolidated Vultee Aircraft Corp.

****

IAS News

A Record of People and Events of Interest to Institute Members

Fourth International Aeronautical Conference

Thirteen Papers to Be Presented During Technical Sessions; Visits to Aeronautical Plants and SBAC Farnborough Show Scheduled

PLANS FOR THE Fourth International Aeronautical Conference, to be held in London, England, from September 7 to 18 under the joint auspices of the Royal Aeronautical Society and the Institute of the Aeronautical Sciences, were rapidly becoming finalized as this issue went to press. Included in the agenda for this meeting are visits to various British air-frame and engine manufacturing plants and to the SBAC Flying Display and Static Exhibition at Farnborough.

▶**Tentative Schedule**—The Royal Aeronautical Society has gone to infinite pains to give the American delegates to the Conference a good cross-sectional view of the British aircraft industry. Among those companies that will probably be visited are: Rolls-Royce, Ltd., at Derby; Vickers-Armstrongs, Ltd., at Weybridge, Surrey; The de Havilland Aircraft Company, Ltd., at Hatfield, Herts; Saunders-Roe, Ltd., on the Isle of Wight; and The Bristol Aeroplane Company, Ltd., at Bristol.

The American delegates are scheduled to arrive in London between September 6 and 8. From September 8 to 11, plant visits and a day at the SBAC Farnborough show have been arranged. On the morning of Monday, September 14, a plant in the general vicinity of London will be visited. The delegates will be returned to London in sufficient time to attend the RAeS's Wilbur Wright Memorial Lecture, which will be delivered late that afternoon by America's Dr. Nicholas J. Hoff, Professor and Head of the Department of Aeronautical Engineering, Polytechnic Institute of Brooklyn. The Wilbur Wright Memorial Lecture will be followed by a reception given by the RAeS.

The technical sessions of the Fourth International Aeronautical Conference will get under way on the morning of September 15, immediately after opening remarks by RAeS President Sir William S. Farren and IAS President Charles J. McCarthy. The sessions will be continued throughout that day and the two succeeding days. The technical phase of the Conference will be concluded on the evening of September 17 with a dinner dance to which the wives of the delegates will be invited.

On September 18, the last day of the RAeS-IAS Conference, a final visit to a British aeronautical plant has been arranged for the American delegates.

▶**Technical Papers**—As of this writing, 13 papers are scheduled for presentation during the 3 days of technical sessions. Seven of these will be delivered by representatives of the British and Canadian aviation industry, and the remaining six will be given by representatives of the American aviation industry. The seven British and Canadian speakers and the papers they will present are as follows:

Dr. N. A. de Bruyne, Managing Director, Aero Research, Ltd.—"Structural Adhesives for Metal Aircraft."

A. C. Campbell Orde, Operations Development Director, British Overseas Airways Corporation—"The Introduction of the Comet into Service."

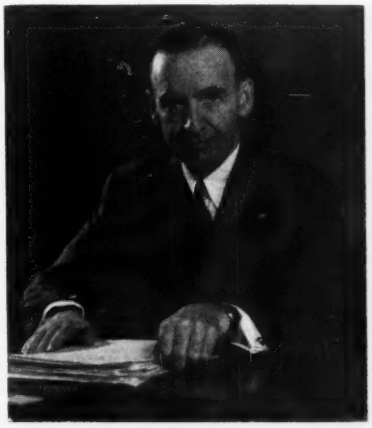
H. Pearson, Chief Research Engineer, Rolls-Royce, Ltd.—"The Aerodynamics of Compressor Blade Vibration."

Captain A. Graham Forsyth, Chief Helicopter Engineer, The Fairey Aviation Company, Ltd.—"Power Plants for Helicopters."

S. D. Davies, Chief Designer, A. V. Roe & Company, Ltd.—"The Development of a Family of Delta Aircraft."

(*Concluded on page 20*)

Sir William S. Farren, RAeS President



Charles J. McCarthy, IAS President

Fourth Southeastern Conference

Three-Day Conference Held by IAS Student Branches

THE FOURTH ANNUAL SOUTHEASTERN REGIONAL CONFERENCE of the Student Branches of the Institute of the Aeronautical Sciences was held at Mississippi State College from April 9 to 11. The schools represented were the University of Alabama, Alabama Polytechnic Institute, University of Florida, Georgia Institute of Technology, Virginia Polytechnic Institute, and Mississippi State College.

Registration was held on the morning of Thursday, April 9. The first session of the 3-day conference was held that afternoon in the Library Auditorium with Hayden F. Glenn, IAS Student Branch Chairman at Mississippi State, presiding. The first paper was presented by F. G. Blottner, of V.P.I., and was entitled "Design, Construction and Calibration of a Small Supersonic Wind Tunnel." The second paper, "A Summary of the Energy Method of Determining Climb Performance of Jet-Propelled Aircraft," was given by S. A. Powers, of Georgia Tech. Following a short intermission, films entitled *Time Lapse Motion Studies of Atmospheric Flows* were shown by Dr. August Raspet, of Mississippi State's Aerophysics Department. These interesting films illustrated various natural airflows using cloud formations as a visual means of observation. The last paper at this first session was delivered by Prof. H. W. S. LaVier, of Georgia Tech, on the subject of "Results of Permeability Studies on Parachute Fabric." In this paper, he discussed research on parachute materials now being carried on at Georgia Tech.

That evening, a banquet was held in the College Cafeteria, after which the group adjourned to the Library Auditorium where Conrad A. Lau, Aerodynamic Project Engineer, Chance Vought Aircraft Division of United Aircraft Corporation, spoke on "The Part of the Aerodynamic Engineer in the Production of an Airplane." In his talk, Mr. Lau covered the part played by each individual engineer in both the design and construction of an airplane. After a discussion period during which Mr. Lau answered several questions, the evening session was adjourned.

The conference was resumed the next morning, April 10, in the Library Auditorium with Gilbert Hoffman, of Mississippi State, presiding. The first paper was presented by A. F. Lampros, of V.P.I., on "Comparison with Experiment of the Various Theories for Location of Detached Shock Waves." The second paper of the day was "The Jet Afterburner" by H. S. Williford, Jr., of the University of Alabama. "Oscillations in the Laminar Boundary Layer" was the subject of the next paper and was delivered by J. S. Hayden, of Mississippi State. The morning session was closed by Prof. Donnell W. Dutton, of Georgia Tech, with a talk on the "History of Helicopter Development."

A sailplane exhibition by the Aerophysics Department at Mississippi State at the Starkville Airport comprised the afternoon program. During the afternoon, techniques in thermal soaring, boundary-layer control, auto towing of gliders, and high-performance sailplanes were demonstrated.

In the evening, a banquet was held at the Lakeside Country Club. After the banquet, Dr. Raspet introduced the guest speaker, Dr. A. M. Lippisch, of Collins Radio Company. Dr. Lippisch explained in his lecture the experimental procedure that he had used in his delta-wing research and some of the conclusions that he had reached. In the films accompanying his talk, these experimental methods were illustrated, and many of the visual results were observed.

A final session was held on Saturday morning, April 11, in the Library Auditorium. The first paper presented was "An Evaluation of the Engineering Application of the Various Two-Dimensional High-Speed Theories" by P. J. Johnson, of V.P.I. The second paper was "The Procedure for the Calculation of the Flight Path of a Rocket-Powered Aircraft at High Mach Numbers" and was given by R. S. Bailey, of the University of Florida. After a brief intermission, the group reassembled to view films, narrated by Dr. Lippisch, on the development of the German rocket fighter, the ME-163. Following these films, T. C. Pope, of Mississippi State, made awards to the students who had presented papers.

A business session was then held during which it was decided that Alabama Polytechnic Institute would be the site of next year's conference. At the conclusion of all business, the conference was adjourned.

THOMAS C. POPE
Secretary
IAS Student Branch
Mississippi State College

This photograph, snapped during the Fourth Southeastern Regional Conference, shows all but one of the conference speakers. In the front row, *from left to right*, are: J. S. Hayden, Mississippi State College; R. S. Bailey, University of Florida; A. J. Lampros, Virginia Polytechnic Institute; Conrad A. Lau, Chance Vought Aircraft Division, United Aircraft Corporation; and Prof. H. W. S. LaVier, Georgia Institute of Technology. In the back row, *from left to right*, are: Prof. Donnell Dutton, Georgia Tech; F. G. Blottner, V.P.I.; S. A. Powers, Georgia Tech; P. J. Johnson, V.P.I., and H. S. Williford, Jr., University of Alabama. Not shown in this picture is Dr. A. M. Lippisch, Collins Radio Company.

Texas Section's First Southwestern Student Competition

IAS President Charles J. McCarthy Speaks at Awards Dinner

THE FIRST SOUTHWESTERN STUDENT COMPETITION, sponsored by the Texas Section of the Institute of the Aeronautical Sciences, was held in Fort Worth, Tex., on May 6–9 with headquarters at the Worth Hotel. During the 4 days of the conference, students from nine colleges presented original papers on aeronautical subjects in competition for prizes. The cost of the conference, including the prize money and travel expenses for the participants, was underwritten by a group of four Texas aircraft companies—Chance Vought Aircraft Division of United Aircraft Corporation, Consolidated Vultee Aircraft Corporation, Marine Aircraft Corporation, and Temco Aircraft Corporation. The students, faculty representatives from eleven colleges, and members of the industry initiated the development of mutual and personal contacts that will facilitate better understanding of common problems and will foster the flow of information between the aircraft industry of the Dallas-Fort Worth area and the participating colleges.

On the evening of Wednesday, May 6, after the registration was completed, the attending students and faculty were welcomed by the Chairman of the Texas Section, William A. Clegern. Following a briefing on the 4-day program by Robert L. Lemmon, Chairman of the Competition Committee, and an outline of the method of judging by Douglas G. Andreoli, Vice-Chairman of the Texas Section, the Secretary of the Section, Howard Marx, introduced films from the sponsoring companies with a humorous monologue, "Movies Are All Alike." Some of the products of the aircraft industry in the area and a cinematic view of typical aircraft engineers at work were presented in these motion pictures of Chance Vought's "Cutlass" and "Regulus," Temco's "Buckeroo," and the engineering department at Convair.

Four sessions were held during the competition, two on Thursday and the other two on Friday. During both of the Thursday sessions, papers on aerodynamics were heard. Those presented in the morning were primarily concerned with stability and control and performance, while those given in the afternoon dealt with theoretical aerodynamics and wind-tunnel testing. Considerations of various design aspects of aircraft and associated systems were covered in the Friday morning session. The actual competition was concluded on Friday afternoon with a discussion of developments relative to propulsion.

During the luncheons on Thursday and Friday, the students, faculty, and guests heard the top engineering executives of the four sponsoring aircraft companies review the opportunities for aircraft engineers in the Fort Worth-Dallas area and specifically in their respective companies. On Thursday, John W. Larson, Engineer at Convair's Forth Worth Division, discussed the advancement of engineers and counseled the students to continue their efforts to develop techniques of presentations, both oral and written, as a necessary complement to the basic knowledge and reasoning power obtained during the years of formal education. Temco's Director of Engineering, H. Gus Erickson, outlined the growth, managerial philosophy, and planned development and expansion of this corporation.

At the Friday luncheon, Raymond Blaylock, Assistant Chief Engineer at Chance Vought, stressed the increase in complexity of modern aircraft, reaffirmed the need for good presentation of technical material, and discussed plans for the future of Chance Vought. Enthusiasm, versatility, and perseverance are the prime attributes desired in an engineer in a young growing company where each engineer may be called upon for all aspects of a project, observed Joseph L. Colosimo, Chief Engineer, Marine Aircraft.

Three of the luncheon speakers, Messrs. Erickson, Blaylock, and Colosimo, along with Herbert Hinckley, Assistant Chief Engineer at Convair, served as judges for the presentation of the papers during the competition.

The contestants, faculty, and committee members were guests of the Fort Worth Chamber of Commerce at a barbecue supper on Thursday evening at Forest Park. Plans for next year, constructive criticism of this first competition, industry-college relations as to hiring and curriculum, and suggestions for mutual support for further IAS-College-Industry activities in the general southwestern region were presented in an informal round-table discussion conducted on Friday evening by Mr. Hinckley.

The winners of the First Southwestern Student Competition are shown with their faculty sponsors. *From left to right,* they are: J. C. Klotz, Faculty, University of Tulsa; Robert R. Wolfe, University of Tulsa, Honorable Mention Undergraduate Division; William H. Shutts, Faculty, University of Texas; E. E. Brush, Faculty, Agricultural & Mechanical College of Texas; Felix W. Fenter, University of Texas, First Place, Undergraduate Division; J. M. Firebaugh, Texas A. & M., Third Place, Undergraduate Division; Karl A. Fayman, Faculty, Parks College; Wilbur Light, University of Oklahoma, Second Place, Graduate Division; Richard Schapker, Parks College, Second Place, Undergraduate Division; L. A. Camp. Faculty, University of Oklahoma; Harry L. Clements, University of Wichita, First Place, Graduate Division; Fred Smith, University of Oklahoma; Honorable Mention, Undergraduate Division; and Melvin H. Snyder, Jr., Faculty, University of Wichita.

S. Paul Johnston, Director of the Institute of the Aeronautical Sciences, complimented the Texas Section and the faculty on this year's competition and expressed his interest and the support of the national office for future IAS activities of this nature.

Temco, Chance Vought, and Convair were hosts to the students and faculty on Saturday for an inspection trip of their facilities. The group traveled by bus from Fort Worth to Grand Prairie to visit Temco and Chance Vought in the morning. After a lunch served by Chance Vought, the group returned to Fort Worth via the new Greater Fort Worth International Airport, where a visit to the local facilities of Convair was made.

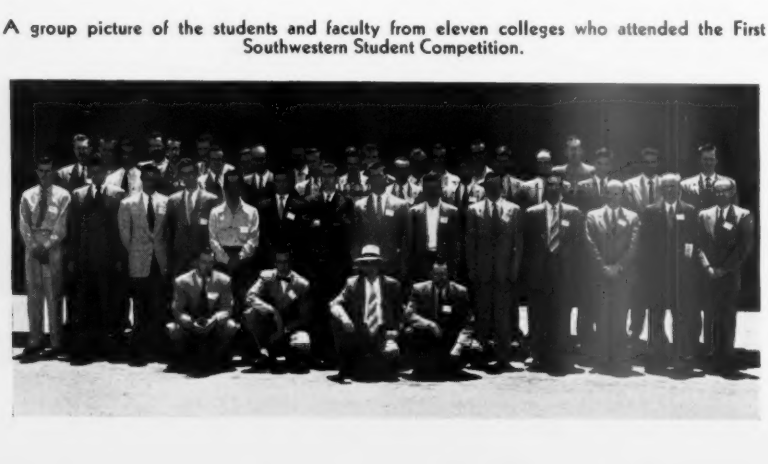
On Saturday evening, May 9, 200 members of the Texas Section and their guests gathered with the students and faculty members for the Awards Dinner in the Venetian Ballroom of the Hilton Hotel in Fort Worth. The principal speaker, Charles J. McCarthy, IAS President and Vice-President of United Aircraft Corporation, emphasized the human side of engineering in his talk on "The Engineering Graduate's Place in Industry." Mr. McCarthy briefly reviewed the past 50 years of aviation history and pointed out that, although the number of engineers relative to production workers has steadily increased, the rapid development of the complexity in aircraft and subsystems has created a demand for engineers which outstrips the present supply. To alleviate this, he suggested the support of engineers with technicians and draftsmen, general orientation of engineers during the initial training program, and continuous training in the fields of organization and supervision so that the engineer can perform his work better through contact with others and be ready for advancement with the company as opportunities arise.

The climax of the 4-day event was the presentation of the awards to the winners by Mr. McCarthy. The prize winners in the competition's undergraduate division and their papers were: *First Prize*, F. W. Fenter, University of Texas, "Methods of Improving the Stalling Characteristics of Swept Wing Aircraft"; *Second Prize*, Richard Schapker, Parks College, "Rocket with After-Burner"; *Third Prize*, J. M. Firebaugh, Agricultural & Mechanical College of Texas, "The Nature of Superaerodynamics"; *Honorable Mention*, Fred Smith, University of Oklahoma, "Engineer's Cruise Control"; and Robert R. Wolfe, University of Tulsa, "Aircraft Production Illustrations." The winners in the graduate division of the competition were: *First Prize*, Harry L. Clements, University of Wichita, "Stability and Control Equations for Preliminary Design"; and *Second Prize*, Wilbur Light, University of Oklahoma, "Ram Jet Development."

The First Southwestern Student Competition was then closed with a resolution of thanks to the Texas Section, IAS, and the supporting companies which was submitted by Prof. Glenn Murphy, of Iowa State College, acting as spokesman for the faculty representatives.

IAS President Charles J. McCarthy, Vice-President, United Aircraft Corporation, Speaks at the Awards Dinner of the First Southwestern Student Competition.

A group picture of the students and faculty from eleven colleges who attended the First Southwestern Student Competition.



F. A. CURTIS, JR.
Cochairman
Publicity Committee
Texas Section

Fourth International Aeronautical Conference

(*Concluded from page 17*)

John Orr, Head, Low Temperature Laboratory, National Aeronautical Establishment of Canada—"The Thermal De-Icing of Aircraft."

R. A. Neale, Vice-President—Manufacturing, Canadair Ltd.—"Basic Prerequisites Essential to Production: People, Plans, Policy, and Plant."

The American authors and their papers to be presented during the technical sessions are:

Preston R. Bassett, President, Sperry Gyroscope Company, Division of The Sperry Corporation—"The Control of Flight."

R. H. Miller, Vice-President—Engineering, The Kaman Aircraft Corporation—"Some Factors Affecting Helicopter Design and Future Operations."

George S. Schairer, Chief of Technical Staff, Boeing Airplane Company—"Mounting of Turbojet Engines."

C. D. Perkins, Head, and David C. Hazen, Professor, Department of Aeronautical Engineering, Princeton University—"Recent Advances in Circulation Control."

Hall L. Hibbard, Vice-President and Chief Engineer, Lockheed Aircraft Corporation—"Structural Materials for High-Speed Aircraft."

R. V. Rhode, Assistant Director, Research, NACA, Washington, D.C.—"Some Observations on the Problem of Fatigue of Airplane Structures."

The technical sessions will be opened only to members of one or both of the two participating societies. The Institute is making the necessary arrangements for its members residing in the United States to attend this RAeS-IAS meeting. All others who desire to attend the Fourth International Aeronautical Conference are asked to contact Dr. A. M. Ballantyne, RAeS Secretary.

IAS General News

Pioneers Committee Formed

A Pioneers Committee of the National Committee to Observe the Fiftieth Anniversary of Powered Flight was formed a short time ago for the purpose of drafting and executing a plan by which nationwide tribute would be paid to those men and women who were the early trail blazers of aviation, Admiral John H. Towers, USN (Ret.), an IAS Associate Fellow and Founder Member, Consultant to Pan American World Airways, Inc., was named Chairman of the newly formed Pioneers Committee.

Serving with Admiral Towers are three IAS members and five nonmembers. The three IAS members are: Major Lester D. Gardner, IAS Founder, Fellow, and Benefactor, Aeronautical Consultant; Major Gen. B. D. Foulois, USAF (Ret.), IAS Member and Founder Member; and Brig. Gen. Frank P. Lahm, USAF (Ret.), MIAS. The other five committee members are Adm. Richard E. Byrd, Will D. Parker, Harry Bruno, Brig. Gen. T. DeWitt Milling, and Ernest L. Jones.

Lieutenant General James H. Doolittle, USAFR, IAS Honorary Fellow and Founder Member, Vice-President of Shell Oil Company, is the Chairman of the National Committee to Observe the Fiftieth Anniversary of Powered Flight.

RAeS Installs New President

Sir William S. Farren, FIAS, FRAeS, Technical Director of A. V. Roe and Company, Ltd., England, was inducted on May 7 as the 1953–1954 President of the Royal Aeronautical Society. This ceremony took place at the Society's Annual General Meeting.

Sir William has been identified with the aircraft industry for nearly 4 decades. The companies with which he has been associated during this time include Armstrong Whitworth, Armstrong Siddeley Motors, and Blackburn Aircraft Company. He served for a number of years on the faculties of Cambridge University and the Royal College of Science. With Sir Melvill Jones, he took part in the research work for which the Department of Aeronautics at Cambridge has received international recognition.

During the first 2 years of World War II, Sir William served as Deputy Director, Research and Development, Aircraft, and as Director of Technical Development at the Ministry of Aircraft Production, Great Britain. From July of 1941 to the end of 1945, he was Director of Britain's Royal Aircraft Establishment. He joined A. V. Roe in 1947.

IAS Staff Changes

The appointment of Thomas J. Meskel, AMIAS, as Assistant Secretary of the Institute of the Aeronautical Sciences was one of three recent IAS staff changes necessitated by the growing IAS membership and the increased IAS Section and Student Branch activities. Succeeding Mr. Meskel in his former position as Manager of the Institute's Member Services is Lawrence J. Prezzano. Mr. Prezzano was previously Assistant Manager of Member Services.

John J. Glennon, AMIAS, was made Librarian of the IAS New York Headquarters. Mr. Glennon has been serving as Acting Librarian since October, 1951, when the former Librarian, Maurice H. Smith, TMIAS, resigned from the Institute's staff to become a Research Associate with the Forrestal Aeronautical Research Center at Princeton University.

Necrology

Mark A. Klinger

Mark Andrew Klinger, TMIAS, Engineer, Piasecki Helicopter Corporation, died on March 29, according to word recently received. Further details of his death were not furnished.

Mr. Klinger was born in Bethlehem, Pa., on June 19, 1927. He attended Bethlehem's Liberty High School from 1941 to 1944. He took his first year of college undergraduate work at Lehigh University. In 1945, he transferred to Parks College and was graduated from there in March of 1948 with a B.S. degree in Aeronautical Engineering.

Immediately after his college graduation, Mr. Klinger went to work at Chase Aircraft Company, Inc., as a Junior Aerodynamicist. About 1949, he became associated with Piasecki Helicopter Corporation, first, as a Junior Engineer with a Shop Liaison Group and, later, as Project Liaison Engineer.

News of Members

▸ **Harry Frank Guggenheim,** IAS Honorary Member, Member, and Benefactor, was the recipient of the American Meteorological Society's Award for Outstanding Service. This award was presented to Mr. Guggenheim at the AMS Annual Banquet on last April 30 and was accompanied by a citation that read "for establishing the first airways meteorological network in America and for his support of meteorological education and research." Mr. Guggenheim is Senior Member of the firm, Guggenheim Brothers, of New York City.

▸ **F. W. M. Moore** (M), Industrial Engineer, Bristol Aeroplane Engines (Eastern) Ltd., was recently elected the 1953–1954 President of the Institute of Aircraft Technicians, Canada.

▸ **E. S. Thompson** (AF), Manager, Contracts, Aircraft Gas Turbine Division, General Electric Company, was elected President of the Jet Pioneers Association at its recent annual meeting in Lynn, Mass.

▸ **Dr. Theodor H. Troller** (AF) resigned on April 15 as Vice-President—Engineering, Joy Manufacturing Company. Dr. Troller, who is moving with his family to the Southwest, will continue to serve Joy Manufacturing from time to time in a consulting capacity.

▸ **Dr. Theodore von Kármán** (HF), Chairman, Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, was one of five persons who on May 4 received Lord & Taylor Awards of $1,000 each. Dr. von Kármán was selected as a recipient of this award "for his sweeping contribution to jet propulsion, aerodynamics, and the whole field of aviation."

▸ **George H. Woodard** (M) has joined Charles H. Welling in establishing a partnership known as Welling & Woodard. This firm of industrial consultants is specializing in new products and diversification and is located in New Canaan, Conn. Offices are also maintained at 52 Vanderbilt Ave., New York, and at 1500 Walnut St., Philadelphia, Pa.

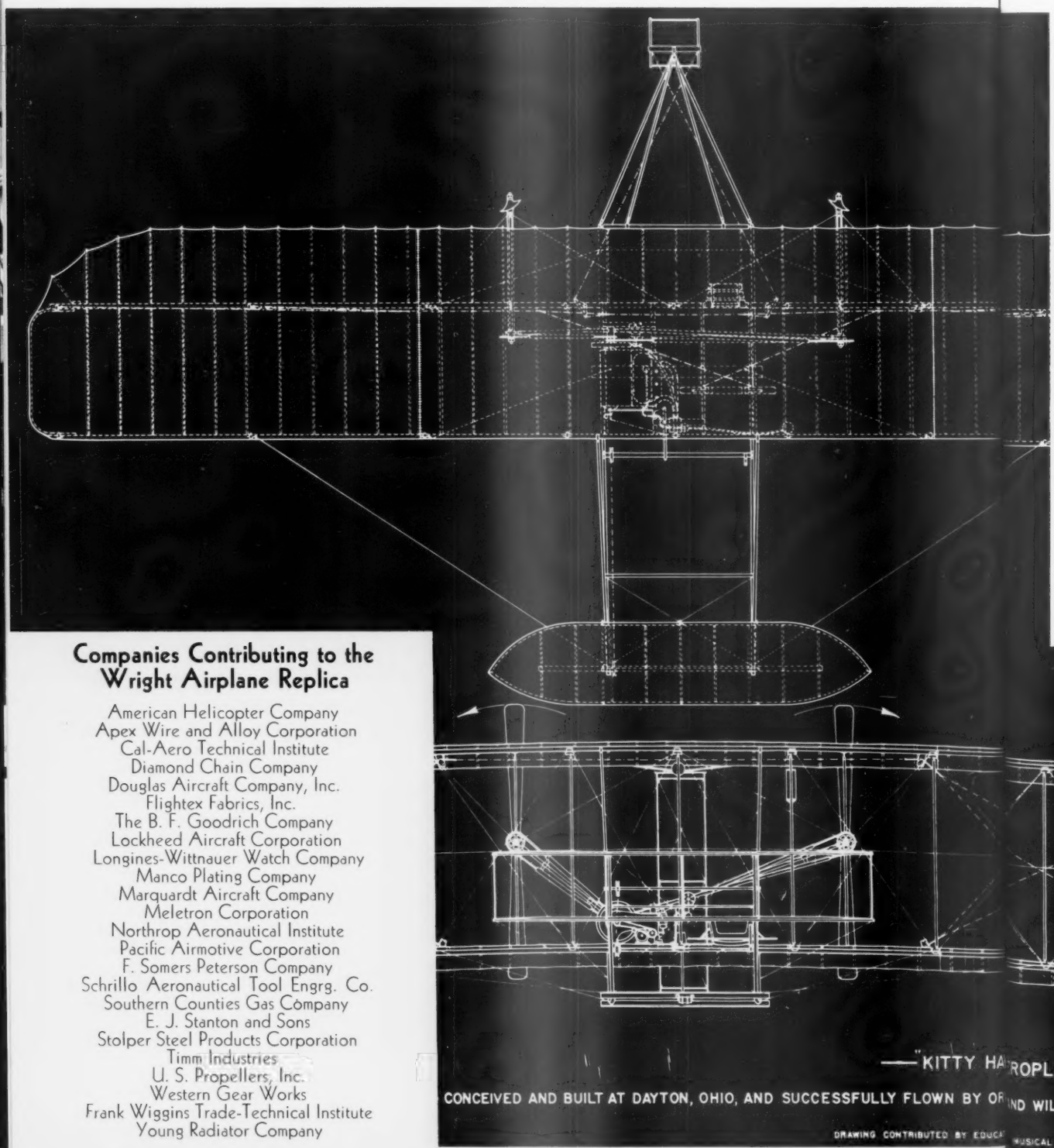
Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are therefore urged to notify the News Editor of changes as soon as they occur.

John D. Alexander (TM), Project Engineer, Bomarc F-99 Pilotless Interceptor, Boeing Airplane Company. Formerly, Assistant Project Engineer, Boeing.

(*Continued on page 64*)

Editorial


—"KITTY HA ROPLA
CONCEIVED AND BUILT AT DAYTON, OHIO, AND SUCCESSFULLY FLOWN BY OR ND WILB
DRAWING CONTRIBUTED BY EDUCA USICAL AI

Companies Contributing to the Wright Airplane Replica

American Helicopter Company
Apex Wire and Alloy Corporation
Cal-Aero Technical Institute
Diamond Chain Company
Douglas Aircraft Company, Inc.
Flightex Fabrics, Inc.
The B. F. Goodrich Company
Lockheed Aircraft Corporation
Longines-Wittnauer Watch Company
Manco Plating Company
Marquardt Aircraft Company
Meletron Corporation
Northrop Aeronautical Institute
Pacific Airmotive Corporation
F. Somers Peterson Company
Schrillo Aeronautical Tool Engrg. Co.
Southern Counties Gas Company
E. J. Stanton and Sons
Stolper Steel Products Corporation
Timm Industries
U. S. Propellers, Inc.
Western Gear Works
Frank Wiggins Trade-Technical Institute
Young Radiator Company

Wright Replica

As of this month, the Institute finds itself in a unique situation. We are now the possessor of the only full-scale replica in the United States of the Wright Airplane that made the first powered flight in December, 1903. As far as we know, the only other replica in the world is the one in the South Kensington Museum in London.

It came about in this way.

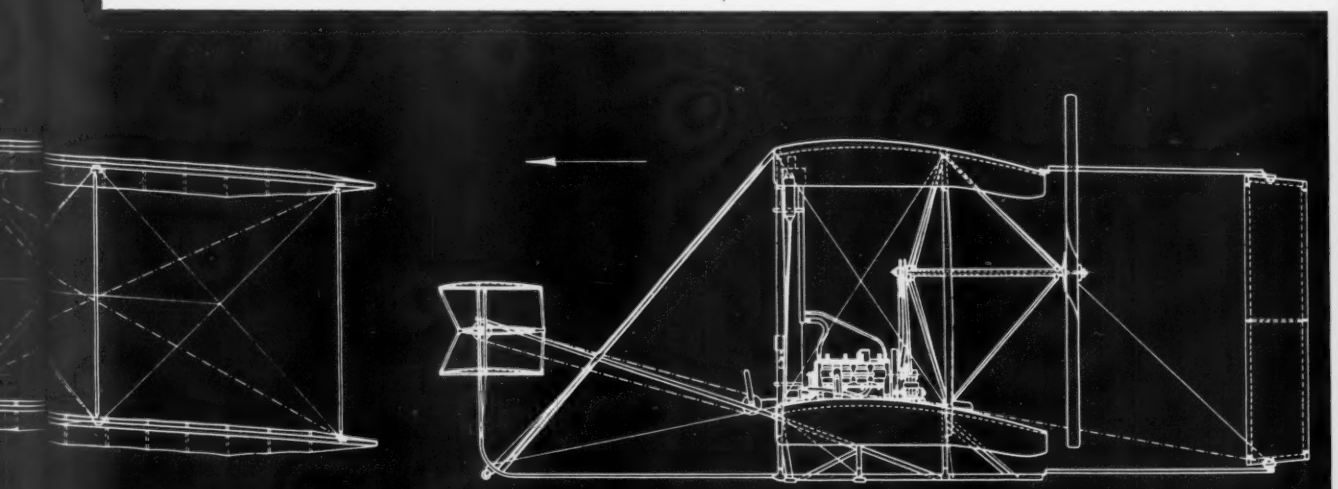
E. W. Robischon, our Western Region Manager, is a long-time collector of historical aeronautical material. Over a year ago, with an eye on the 50th Anniversary celebration of this year, he conceived the idea, not of a model of the Kitty Hawk, but a full-scale replica to be permanently housed in our Los Angeles Building. This appeared to be a bit impractical at first. Airplanes, even dummies, cost money, and, besides, who could be interested in building anything but 1953 airplanes in 1953! Nothing daunted, "Robie" rang bells, wrote letters, and dialed telephones. Somewhat to his surprise the idea took hold, and almost before he knew it he had a group of 24 companies, each of which had undertaken to build certain units for the machine to be assembled eventually by the boys of the Northrop Aeronautical Institute. (The contributing companies are listed on the opposite page.)

As time went on, strange bits and pieces began to turn up around the Los Angeles Building. One might find a wooden rib or two standing in a corner or a strange looking gas tank under a desk. When "Robie" went abroad in February (to expert a bit in the field of aeronautical documentation for Dr. von Kármán, of AGARD), Al Cleveland, of Lockheed, picked up the project, and presently the stray parts began to take real shape. By the end of June the job was complete and the airplane rolled out of the hangar.

At the Summer Meeting Dinner on July 15, the machine will be unveiled with appropriate ceremonies. IAS Past-President, James H. Doolittle, Chairman of the National 50th Anniversary Committee, will do the job. Full account of this event will appear in a later issue of the REVIEW and in our historical magazine, AERONAUTICA.

Plans are afoot to exhibit the airplane in various places around the country, possibly even on the sand dunes at Kitty Hawk. Shortly, however, it will be returned to be suitably displayed in our Los Angeles Headquarters Building as a constant reminder of the determination of Wilbur and Orville Wright to make a century-old dream come true. Every member of the IAS may well be proud of this addition to our collection of aeronautica. Our thanks and appreciation to "Robie" and to Al Cleveland for a most appropriate idea carried to a successful conclusion.

S. P. J.



ROPLANE —

ND WILBUR WRIGHT, DECEMBER 17, 1903, AT KITTY HAWK, NORTH CAROLINA.

MUSICAL ARTS, INC., DAYTON, OHIO. HARVEY D. GEYER, TECHNICAL ADVISOR, ORVILLE WRIGHT ESTATE DRAWING NO.

Guided Missiles

Comments on Surface-Based Antiaircraft Missiles

HENRY H. PORTER

Applied Physics Laboratory, The Johns Hopkins University

Introduction

Guided missiles is a broad field. Its possibilities have caught many imaginations, and guided missiles have been dreamed up for every conceivable use and every pocketbook, provided, of course, that the pocketbook is big enough.

It would be futile to try to cover the whole field so I shall limit my remarks primarily to surface-based antiaircraft missiles.

All weapons should start from a tactical need, and each weapon, if effective, is soon met by countermeasures. Early in the first World War planes were used primarily for reconnaissance. However, the sporting blood of the pilots called for combat, and it is said that the first missiles used were bricks. Thus, the lowly brick is a direct ancestor of the modern guided missile. Sometimes missiles seem to behave like their ancestors and fly like bricks. Subsequently, pistols and machine guns were used in air-to-air combat, and antiaircraft guns were used from the ground.

Since then, antiaircraft guns have been greatly improved; proximity fuzes have increased the effectiveness of the system; radar accurately locates the target; computers, from a knowledge of the shell trajectories and the past target course, predict the point of intersection and aim the guns. But this is a losing battle. The increased speed of planes, plus the possibility of guiding bombs to the target, a possibility that would permit them to remain at long ranges, will render antiaircraft guns ineffective. At a range of 5 miles, a fast plane will fly over 2 miles after the shell leaves the gun and before it arrives at the plane, and few pilots are skillful enough to fly that distance accurately enough to be hit by a perfectly aimed shot. These considerations show the need for guiding the missile to the target.

The primary characteristics needed in a guided missile are range, accuracy, and damage potential. To be tactically useful, other requirements are: speed, automatic control, traffic capacity, reliability, and low cost for the effect achieved.

Fortunately, scientific progress has developed in many fields to the point where it is possible to combine and extend them to make guided missiles work. These fields include rocketry, jet propulsion, supersonic aerodynamics, structures, miniaturized electronics, servomechanisms, electronic computers, and radar.

Address delivered to the Washington Section, Institute of the Aeronautical Sciences, December 2, 1952, Washington, D.C.

Design of an Antiaircraft Missile

Let us make a rough preliminary design of an antiaircraft missile to get a feeling for the problems.

First, we must provide an air frame, light yet tremendously strong and rigid, with lifting and control surfaces capable of high maneuverability at great altitudes, yet controllable also at sea level—that is, through a range of air densities of about 10 to 1.

We must also provide a warhead. Present antiaircraft shells weigh from 15 to 100 lbs., but, since we are using a much larger and more costly missile, we want to assure high kill probabilities. Also, airplanes are becoming more rugged. We will probably want to allow something in the neighborhood of 100 to 500 lbs. for the warhead.

To guide the missile to within lethal distance of the target we must provide room for an amazing guidance system. It must be accurate; it must average out the errors fed to it; yet, it must be fast enough to follow the target's evasive maneuvers.

We must also allow space for the control system. This includes the power and mechanisms for moving the control surfaces, plus the computers to make the missile stable and maneuverable at all altitudes and yet prevent excessive aerodynamic forces from being imposed at low altitudes.

Propulsion Systems

We must also provide space for a propulsion system. As a first approximation, let us assume a missile diameter of 2 ft. If we optimize the length and shape and provide lifting and control surfaces, this missile will have a drag of about 6,500 lbs. at a velocity of twice the speed of sound. This will require a propulsion system capable of providing over 25,000 hp., packaged inside our 2-ft. missile, yet one that is light and reliable.

The first propulsion system that comes to mind is a rocket, which has the characteristics of thrust and size needed. The solid rocket is quite simple in principle. It consists of a chamber in which the propellants burn at high pressure and a nozzle through which the jet acts. In going to large sizes, the chambers become heavy since the high-pressure chamber, which must contain the propellants, becomes large. In a liquid

rocket, the combustion chamber can be kept comparatively small and light since the propellants are stored outside the chamber, but this requires pumps, fuel metering, and other complications. All this has favored the use of solid rockets for small, short-range uses and liquid fuels for larger rockets. The German V-2 was a liquid-fuel rocket. Recent advances in the techniques of solid-fuel rockets, however, have made them competitive, particularly if the handling problems of the corrosive liquid propellants are considered. By its nature, a rocket must also carry the oxidizer, as well as the fuel. Since this is several times the weight of the fuel itself, only a rather low specific impulse of 200 lbs. sec. per lb. of propellant is attained—i.e., 1 lb. of propellant will supply 200 lbs. thrust for 1 sec. or 1 lb. thrust for 200 sec. If we assume a time of flight of 60 sec., which means a range of about 20 miles for the hypothetical missile we were designing, we will require about a ton of fuel and oxidizer ($6{,}500 \times 60/200 = 1{,}950$ lbs.).

This rough approximation shows that, while rockets are good for short-range missiles, the propellant weight becomes excessive where long range is needed. By far the greatest amount of the propellant is the oxidizer. Thus, if we could use air as the oxidizer, the amount of propellant to be carried would be greatly reduced. Engines that do this are the pulse-jet, the turbojet, and the ram-jet (Fig. 1). These are modifications of the rocket idea to admit air into the combustion chamber to burn with the fuel.

The pulse-jet operates intermittently, admitting air to the combustion chamber through valves that automatically close to contain the explosion pressure and force the jet out the nozzle. The pulse-jet was used by the Germans in the V-1. It is not an efficient propulsion system for supersonic speeds.

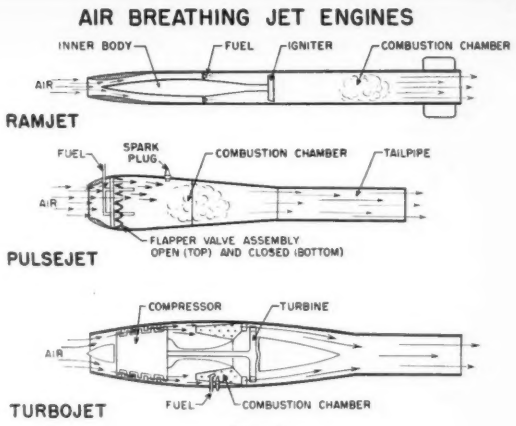


FIG. 1.

The turbojet, which is now commonly used in jet aircraft, uses a turbine compressor to force the air continuously into the combustion chamber under sufficient pressure to eject the jet of combustion products through the nozzle.

At supersonic speeds, the ram pressure of the air due to the velocity of the missile will provide enough pressure to make the jet engine effective. The ram-jet is thus a simplified turbojet in which the compressor is not needed, but it only gives thrust at high velocities and is ineffective much below its designed speed. Because of its simplicity, however, the ram-jet can be very light, providing several horsepower per ounce. Its fuel economy also is good, since it attains a fuel specific impulse of about 1,200 lbs. sec. per lb., or about six times as much as a rocket. It therefore needs to carry only about one-sixth of the propellant a rocket requires, or, in our hypothetical missile, a ram-jet would only need about 330 lbs. of fuel instead of a ton. The propellant weights are estimated for low-altitude

FIG. 2. Large ram-jet launched at the Naval Ordnance Test Station, Inyokern, Calif. Its velocity was "far into the supersonic range." The ram-jet is boosted to near the speed of sound by a solid-propellant rocket, which falls away, and the ram-jet engine takes over. It was developed for the Navy Bureau of Ordnance by The Johns Hopkins University Applied Physics Laboratory and its associate contractors.

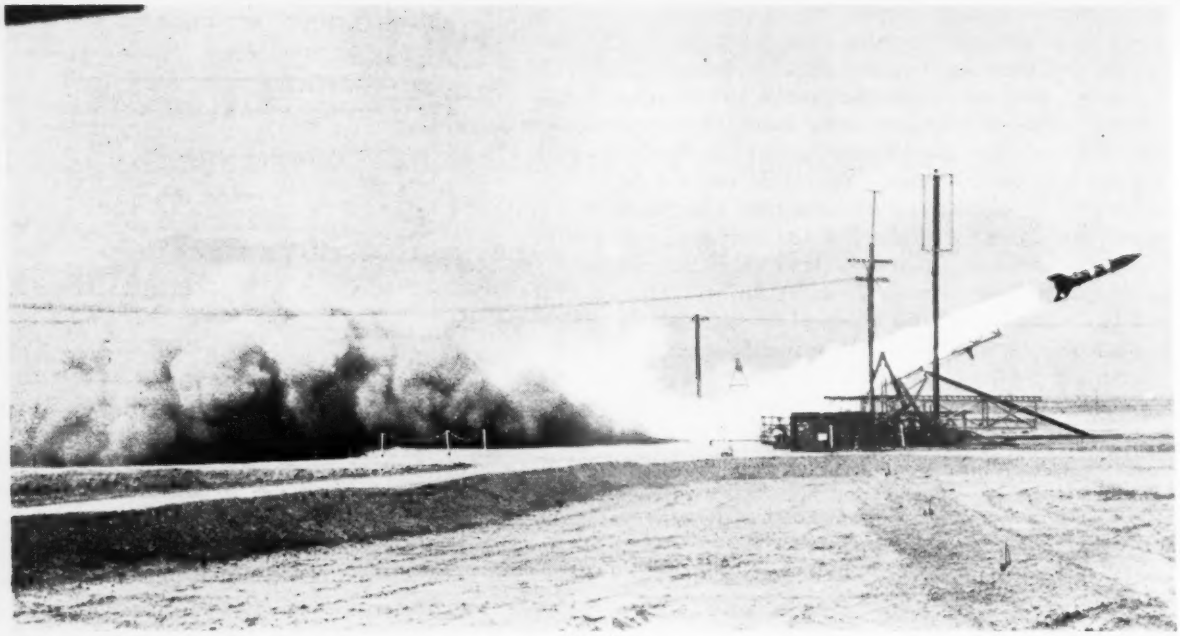


FIG. 3.

flight. At high altitudes, the drag is less, and less propellant is needed.

Thus, it appears that the ram-jets (Fig. 2) are much better than rockets. However, the decision is not always so simple. For this comparison, we have assumed an aerodynamic flight path, one similar to the flight an airplane would make. If a ballistic trajectory similar to a shell is considered, this considerably modifies the comparison in favor of rockets and extends the range at which rockets are competitive, but this in turn imposes certain limitations on the guidance system. In all, the rocket seems best for short-range and the ram-jet for long-range antiaircraft missiles. The only discussion is over the range at which this division comes.

So far we have only considered the missile in flight. There is also the problem of launching the missile and accelerating it to flight speed. For antiaircraft use, where time is of great consequence, it is important to spend as little time as feasible in attaining flight velocity. This is being done by means of large rockets (Fig. 3) which accelerate the missile to flight speed in a few seconds and then generally separate, leaving the missile to fly on unencumbered.

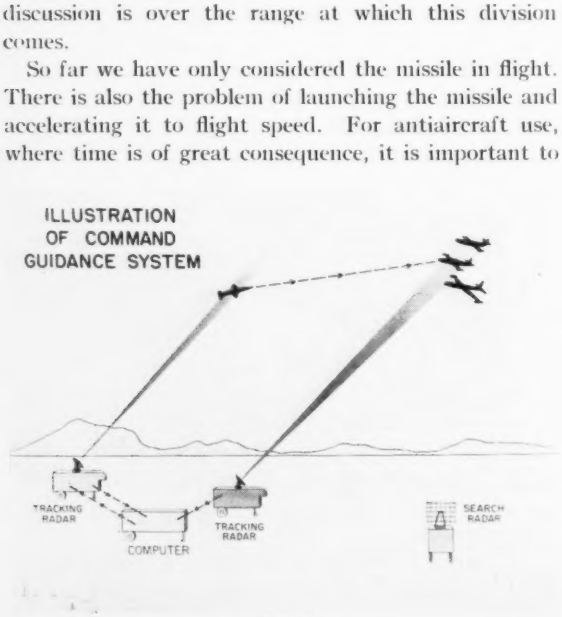


FIG. 4.

Guidance Systems

There are a number of possible guidance systems. The choice varies with the tactical conditions and the philosophy of use. These can be divided into systems where the brains are built into the ground equipment, into the missile, or divided between them.

One philosophy is to make the missile as moronic as possible so that as little as possible is lost with each missile. Therefore, the brains are built into the ground equipment, and the missile only has to follow orders. It therefore is generally known as the Command System (Fig. 4). The ground guidance installation must include: equipment for tracking the target, generally a radar; another equipment for tracking the missile; a computer to determine the commands that should be given to guide the missile to the target; and a communication link to the missile. In this system, the compromise has been made in favor of complicated and expensive ground equipment that can be used many times over.

Another system is to divide the brains between the ground equipment and the missile so as to reduce the ground equipment without overcomplicating the missile. The Beamrider is an example of this (Fig. 5). Here, the ground guidance equipment consists of a radar that tracks the target. The missile has enough intelligence to center itself in the radar beam. In both the Command and Beamrider systems the accuracy falls off at long range.

The final step is to put the brains in the missile. This means building a target-seeking system into the missile (Fig. 6). This will prove necessary in very long-range missiles, since homing accuracy is not necessarily dependent on the distance from the launching site. These systems are complicated, however, and often need mid-course control to guide them to the vicinity of the target. The homing problems can be appreciated when you consider that the missile and target are closing at a rate of about 1 mile every 2 sec. so that little time is available for the homing system to locate the target and make all corrections required to achieve a "hit."

Air Defense

Guided-Missile Systems

So much for the missiles themselves. They are only a comparatively small part of a guided-missile system. I have mentioned the guidance equipment required, but, in addition, launchers, handling equipment, stowage, and test equipment are necessary. Even all this is only a part of the system. It must be integrated into an overall air-defense system, including detection of enemy attack, identification of the attackers as hostile, display of the situation, analysis of the attack, and allocation of the role each defending unit is to play.

To see what is involved in such a defense system, let us make some assumptions and view the overall situation. It must be remembered that there is no such thing as a static defense. A defense today may be useless next year. All we can do is plan our defenses to meet the attack that an enemy can throw against us. Therefore, I shall make assumptions for a hypothetical situation, not based on any particular developments or time, primarily to select round numbers that make the calculations simple. Let us assume that the attacking planes fly at 600 miles per hour or 10 miles per min., that the guided missiles fly twice as fast as the planes, and that they have a range of 50 miles.

Since the bomb travels some distance after release, we must destroy the attacker before he reaches the bomb-release line, which is at least some 5 miles from the target (Fig. 7). An important target will probably be defended by several missile sites surrounding the city, about 25 miles out. Since the missile range is 50 miles, the first missile will intercept the attacker 75 miles from the defended point, or 7 min. from bomb-release. Moreover, since the attacking planes fly 25 miles during the time the missiles are flying 50 miles, the missiles must be launched when the planes are 100 miles from the target.

If the missiles must be fired when the attackers are 100 miles from the target, the missile site must be warned earlier in order to man the equipment, ready the missiles, and fire (Fig. 8). If we allow 5 min. for this, the missile site must be alerted when the attackers are 150 miles from the target, or 14.5 min. from bomb-release line. Furthermore, in order to alert the missile

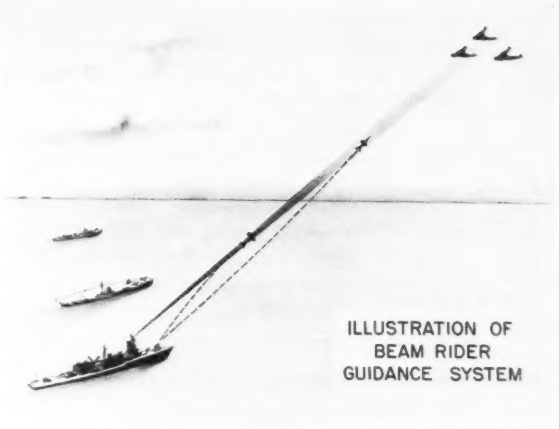


Fig. 5.

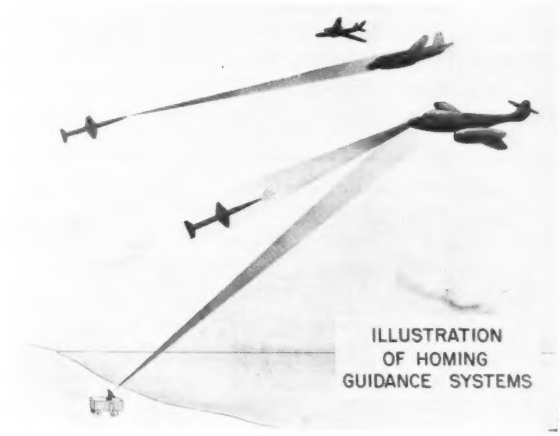


Fig. 6.

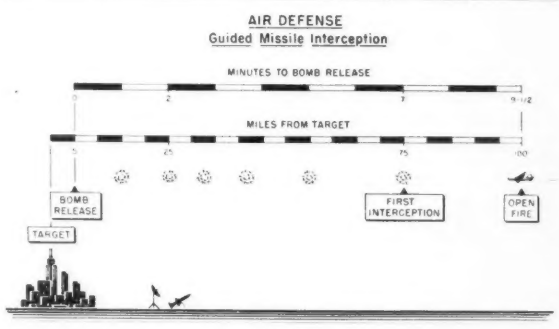


Fig. 7.

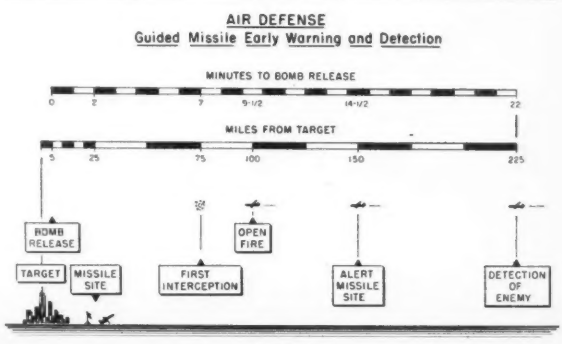


Fig. 8.

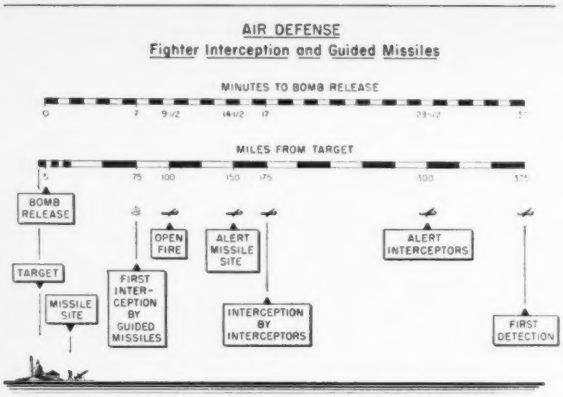


FIG. 9.

site, the enemy planes must be detected and tracked; the attack must be analyzed, and the defense moves allocated to the defending units. Time allowance for this means that the enemy should be detected 225 miles from the target.

Interceptors

So far, we have considered only the guided-missile systems, but we will also want to use interceptors (Fig. 9). They should operate beyond the range of the guided missiles; so they must complete their attack before missile-intercept range, 75 miles from the target, to avoid confusing the defense. If we allow 10 min. for the entire interceptor engagement, they must intercept the attackers at 175 miles. Now, the interceptor bases need alerting to provide time for the interceptors to be manned and climb to altitude; therefore, they must be alerted when the attacking planes are 300 miles from the target. Time for early warning, identification, and display means that the enemy must be detected about 375 miles from the target or 37 min. from bomb-release.

These distances sound big, but, to get a clear realization of how big, let us take Washington as the enemy's target and use various points northeast of Washington to indicate how far away each stage of the attack takes place (Fig. 10).

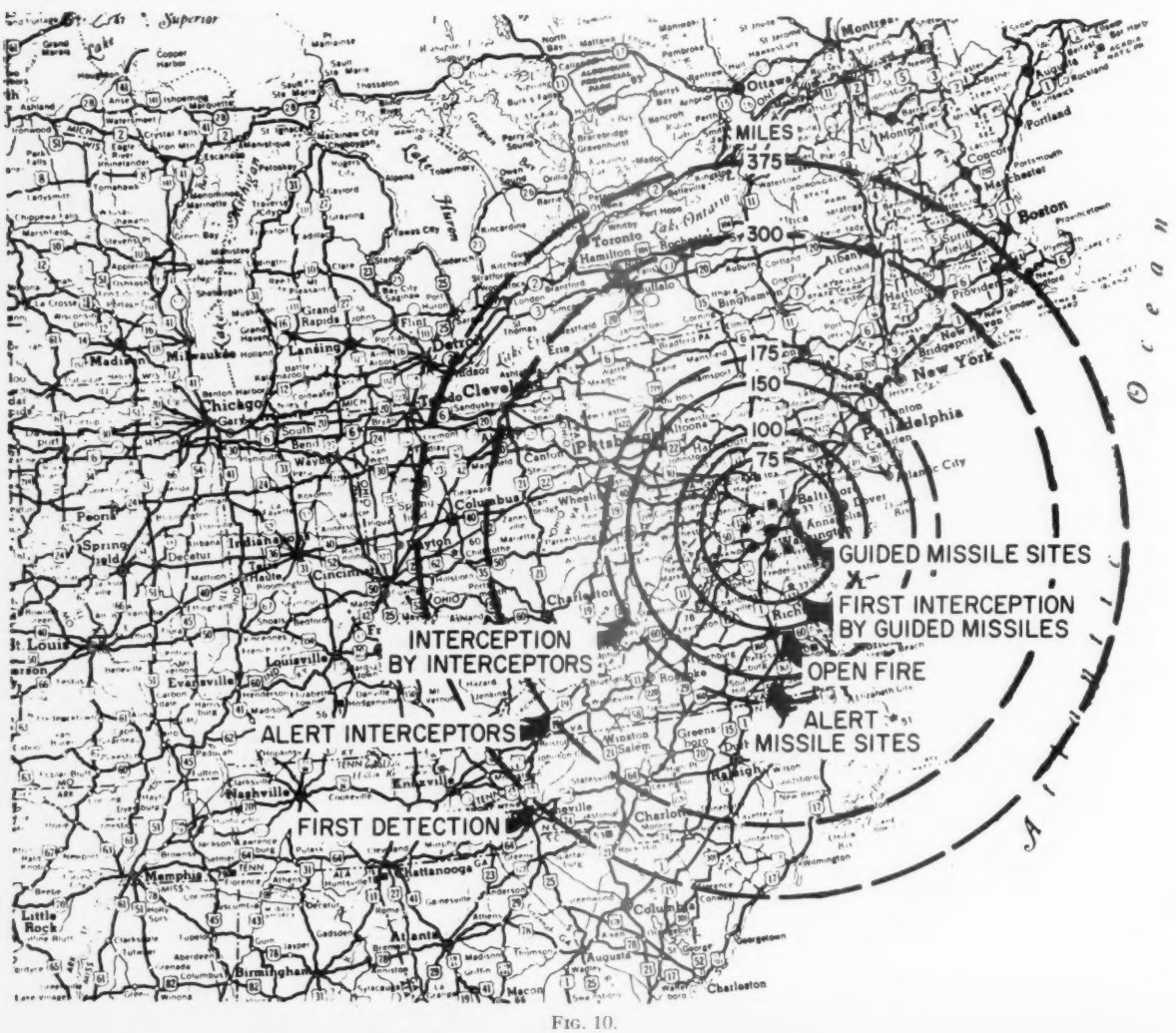


FIG. 10.

The enemy attack must be detected over Boston. The interceptors' base must be alerted when the enemy reaches Hartford, Conn. The interceptors reach the enemy over Newark, N.J. The guided missile site is alerted as the attackers reach Trenton, N.J.; the first missiles are launched as the enemy approaches Wilmington, Del., and the first enemy planes are shot down by guided missiles near Elkton, Md. This is the scale of the action under the hypothetical conditions we have assumed.

Costs

It would not be complete to discuss guided missiles without giving some consideration to the economics involved. One is too prone to compare the cost of one missile to the cost of one shell and feel convinced that one cannot afford to use them. This is not a reasonable comparison. At the least, one should compare the cost of destroying an enemy plane by each method. Since, at the altitudes of expected attacks, guns do not have a high probability of kill per shot, it is not surprising to find that guided missiles will bring down more enemy planes than guns for a given amount of money expended for ammunition. In other words, a stock of guided missiles will shoot down more enemy planes than a stock of antiaircraft shells of equivalent cost.

It is true that in a single heavy attack a far greater cost could be expended by the guided missiles launched than that expended by any available number of guns. Under these conditions, too, guided missiles cost less per plane shot down, and the high cost is a criterion of the extremely high level of defense. Past experience has indicated that an attrition level of 5–10 per cent provided an adequate defense, but now a near-perfect defense is needed. Guided missiles give promise of such a defense.

But the missile cost is only a part of the economic situation. The cost of the equipment and the annual cost of operation must also be considered. For frequent heavy attacks, the missile cost is important, but for few small-scale attacks it may account for less than 10 per cent of the overall cost, even if the capital costs are amortized over several years.

It turns out that for most systems—guns, guided missiles, and interceptors—the capital cost is about twice the annual operating cost, or, if the capital costs are amortized over 4 years, they contribute an additional 50 per cent to the cost of the annual operation. Thus, it turns out that the major costs of any defense system are the men and their support.

This points out the advantages of long-range systems that require fewer installations to cover the same area. But the longer the range, the higher the cost; the fewer the installations, the easier they can be saturated or destroyed. The basic problem is to use the funds available to provide the best defense for the attacks the enemy can make. This defense must include all weapons that contribute usefully and must provide for continuing improvement to meet the threat of a possible enemy's increasing capabilities.

IAS Twenty-Second Annual Meeting

Authors wishing to have papers considered for presentation at this meeting should submit outlines or short abstracts to the Meetings Committee, 2 East 64th St., New York 21, N.Y., no later than September 15, 1953.

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Effects of Articulated Rotor Dynamics on Helicopter Automatic Control System Requirements*

CHARLES W. ELLIS†

Kaman Aircraft Corporation

ABSTRACT

In order to provide a better understanding of some of the limitations and requirements imposed on any stabilization or control device by the conventional type of articulated lifting rotor, a theoretical investigation was carried out to determine the influence of such a rotor on the dynamic properties of a stabilized helicopter. This investigation indicated that any analysis of a high-gain attitude stabilization scheme should include the dynamics of the rotor; it also indicated that simplified methods of considering the effects of such rotor dynamics were feasible.

In conjunction with this theoretical investigation, an experimental program was carried out. Comparison of theoretically predicted and experimentally measured helicopter dynamics indicated the validity of the simplified methods considered and bore out the conclusion that rotor dynamics should be included in high-gain attitude stabilization analyses.

(I) INTRODUCTION

AUTOMATIC STABILIZATION AND CONTROL of helicopters is presently a field of great activity. Until recently, the problems in this field had been approached primarily from the experimental point of view. Only now are concerted efforts being made to bring the analytical side of the art to a status of development comparable to that reached in the fixed-wing field. It is the purpose of this paper to point out one of the pitfalls which may waylay the investigator in this field, to present for consideration a method of avoiding this pitfall, and to present some experimental data verifying the conclusions reached theoretically.

(II) PROBLEMS OF ANALYTICAL DESIGN

In developing an analytical design method for automatic control systems, it is necessary that the designer be able to represent mathematically or graphically the behavior of each component of the system under the influence of various stimuli. Since two important criteria in automatic control projects are stability and speed of response, the dynamic behavior of system components is of particular interest. It is now well known that certain relations between the dynamic responses of the various components must exist if satisfactory operation of the overall system is to be obtained. A requirement, therefore, of any analytical design technique for helicopter control work is a knowledge of the dynamic behavior of the helicopter and its associated automatic control equipment. The dynamics of gyros, servomechanisms, and other automatic control equipment are well known. The missing link is a proved method of analytically representing the helicopter.

As previously mentioned, the helicopter dynamics may be represented either graphically or mathematically for use in analytical design methods. Graphical representation implies that such dynamics have been experimentally measured; thus graphical techniques are not applicable to design studies that are made prior to the construction of a particular machine. Since such studies may be desirable when designing a special-purpose device, it becomes necessary to have suitable mathematical methods of representing helicopter dynamics available to the designer.

This particular problem has been explored theoretically by numerous investigators; however, little experimental correlation of such investigations has been reported. Many of these theoretical studies have been devoted to determining simplified methods of predicting helicopter dynamics. One particular simplification that seems to be widely accepted is the quasi-static rotor assumption, which removes the dynamic characteristics of the tip-path plane by assuming the rotor plane to have the same angular velocity as the rotor shaft. This simplification is entirely suitable for determining the period and damping of the low-frequency oscillation of the helicopter and for representing the helicopter in design analyses of low-gain attitude feedback systems. However, it was indicated by R. H. Miller[1] that such an approximation could only be justified for control feedbacks of less than 0.25 deg. of cyclic pitch change per degree of attitude error.

At the present, the question of desirable magnitudes of control feedbacks is still unresolved, mainly because of the difficulties encountered by investigators attempting to use high gains (near unity) to obtain comparative data. The author feels that desirable ratios probably depend on the particular application of the stabilized helicopter and that only comparative flight tests can provide the final answer. Since this is true, systems capable of satisfactory operation up to feedback ratios

Presented at the Rotating Wing Aircraft Session, Twenty-First Annual Meeting, IAS, New York, January 26–29, 1953.

* The author wishes to express his gratitude to Prof. R. H. Miller, who inspired and directed the investigations; to the Aeronautical Engineering Department at M.I.T., which sponsored the original work; to Kaman Aircraft Corporation, which made possible the preparation of the paper; and to the BuAer, U.S. Navy, which kindly allowed the use of Kaman dynamics data.

† Test and Development Engineer.

of $1^1/_2$ should be designed. To accomplish this the controls designer must understand the requirements imposed on him by helicopter dynamics. It may be considered, by virtue of successful work to date, that suitable means of representing low-feedback helicopter dynamics exist. The pressing problem, therefore, is an understanding of the modifications that the rotor dynamics may impose on a stabilization system designed for high feedback ratios.

If the designer uses the equations of motion for the helicopter which include rotor dynamics such as those given in reference 1, he finds that his work is indeed tedious and difficult. For example, representation of the hovering helicopter in pitch or roll including rotor dynamics involves the solution of four simultaneous differential equations; this involves the expansion of a four-by-four determinant and the factoring of a seventh-order polynomial. Representing the longitudinal dynamics of the helicopter in forward flight involves the solution of five simultaneous differential equations requiring the expansion of a five-by-five determinant and the factoring of an eighth-order polynomial. Such algebraic labor is tedious, difficult, and uneconomical. It therefore behooves the analyst to have at his disposal more easily applied methods of analysis. As will be discussed more fully in the next section, direct representation of the complete helicopter and rotor dynamics by analog computation is not the ideal solution.

(III) Methods of Attack

In approaching this problem of the effects of rotor dynamics, both theoretical and experimental procedures were used. Both are described below.

(A) Theoretical Analysis

The theoretical investigation followed the four steps outlined below:

(1) Use of helicopter equations of motion neglecting rotor dynamics to synthesize an automatically stabilized system.

(2) Use of helicopter equations of motion including rotor dynamics in a similar system.

(3) Comparison of boundaries for satisfactory operation of the two systems to determine the effects of rotor dynamics.

(4) Use of a simplified technique for including rotor dynamics in a similar system to determine the degree of success of the approximation.

The individual systems were analyzed using the roots locus technique of W. R. Evans.[2] This method has the great advantage of displaying on a single plot the variation of the roots of a linear feedback control system as the feedback is varied from zero to infinity. Although perhaps somewhat more difficult to interpret accurately than the conventional frequency response (or Nyquist) diagrams, this ease of display makes the technique ideal for survey studies such as this.

As mentioned previously, analog computation was not particularly applicable to this problem; the presence of two greatly different modes or frequencies in the equations of motion, one representing the low-frequency helicopter shaft motions and one representing the rotor, is extremely difficult to simulate satisfactorily. If done on a repetitive solution analog computer of the suppressed-time-scale variety, one finds great difficulty in choosing a time scale that allows a satisfactory computing interval without causing rotor dynamics to be obscured by computer component dynamics. If done on a real-time-scale machine of the REAC variety, the time scale must also be adjusted to avoid computer dynamics. Here computer drift and excessively long solution times are limiting factors. The author also feels that real-time computers are too accurate and too slow to be justifiably congested by survey studies of this nature which can be more swiftly handled by graphical techniques or, in most cases by suppressed-time simulation.

All the theoretical studies were carried out for the longitudinal dynamics of a typical helicopter [see Appendix (I)].

(B) Experimental Verification

A partial experimental verification was carried out in two phases. The first phase, performed at Massachusetts Institute of Technology under the sponsorship of the Aeronautical Engineering Department, consisted of measuring the dynamics of a limited-freedom model helicopter. The attitude response of the model to cyclic pitch control inputs was experimentally determined by both sinusoidal control excitation and pulse-type transient analysis techniques. The experimental frequency responses were compared with theoretical responses computed by the three methods outlined in Section (III A).

The second phase of the experimental work was carried out at Kaman Aircraft Corporation under the sponsorship of the Bureau of Aeronautics, U.S. Navy. Dynamic response data measured on a Kaman helicopter by pulse input transient analysis techniques were compared with theoretical data for the same helicopter.

(IV) Assumptions and Limitations

In addition to the usual linearizing and simplifying assumptions necessary to reduce the equations of motion of the helicopter and rotor to an easily handled form,[1] it was necessary to set up certain criteria for applying the roots locus method to the problem. These criteria may be most easily discerned from an examination of Fig. 1, a plot of the real-imaginary plane upon which the roots locus is displayed. On Fig. 1 are superimposed times to one-tenth amplitude of exponential roots and natural frequencies and damping ratios of second-order oscillatory roots. In general, it appears that the best transient response will be obtained when the real parts of all roots are as large negatively as possible and when all oscillatory roots are as well damped as possible. A rule of thumb, adapted from the frequency response

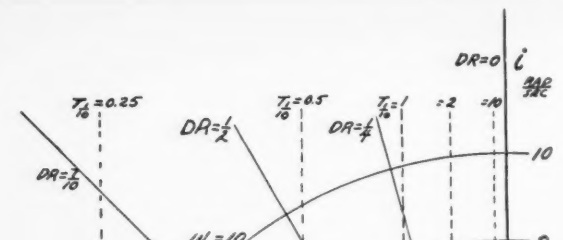


FIGURE 1
PORTION OF COMPLEX PLANE SHOWING FREQUENCY, DAMPING RATIO, AND TIME TO ONE-TENTH AMPLITUDE

methods, indicates that the lowest natural frequency roots should have approximately seven-tenths critical damping for fastest response.

Since these criteria are rather arbitrary and sufficiently vague to require a good deal of judgment in their application, it was decided to modify them somewhat for the purposes of simplicity during this investigation. For purposes of comparison on noncontroversial grounds, neutral stability of any mode was assumed to be the determinant of satisfactory operation. While the system would be unsatisfactory at lower values of feedback than those specified by such a neutral stability criterion, there could be some question of exactly how unsatisfactory the operation would be. With the neutral stability boundary as a basis of comparison no such question exists, and the value of feedback so determined represents an absolute upper limit; the system must actually be operated considerably below this feedback to be completely desirable.

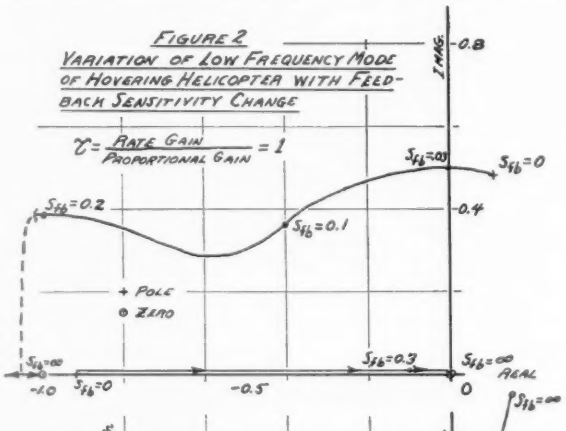
The theoretical equations used in these investigations assumed no coupling between longitudinal and lateral motions. The experimental work was done using a coaxial rotor on the model test rig and with a synchropter-type contrarotating configuration on the full-scale Kaman tests. The experimental and theoretical work should therefore be directly comparable; the results, in general, then apply only to similar configurations. It is generally assumed, however, that any helicopter exhibiting loose longitudinal-lateral coupling may be covered by this work.

(V) Simplified Rotor Dynamics

As noted in Section (II), rigorous treatment of the rotor tip-path plane dynamics involves a great deal of algebraic effort. It was suggested by D. E. Kendall* that these rotor dynamics might be more simply treated by considering the rotor tip-path plane dynamics to be unaffected by motions of the helicopter and to introduce rotor static effects via the quasi-static rotor assumptions. This assumption allows rotor dynamics to be computed neglecting any motions of the rotor shaft and helicopter dynamics to be computed by relatively simple quasi-static rotor methods. The complete helicopter-rotor dynamics are then obtained by a simple multiplication of transfer functions—i.e., rotor transfer function multiplied by the helicopter transfer function. This approximation reduces the algebraic labor by several orders of magnitude. It also considerably simplifies the insertion of rotor dynamics into suppressed-time analog studies.

The intuitive justifications for this method are those justifications used for neglecting the rotors—namely, that the rotor transient is much more rapid than the helicopter transient and that any instability brought about by the rotor dynamics would probably be at such a high frequency that little angular or translational motion of the rotor shaft would occur.

* Formerly Instructor, M.I.T.; now Staff Engineer, Kaman Aircraft Corporation.



Actual justifications are, of course, to be found only in the experimental and theoretical results.

(VI) Results of Theoretical Studies

(A) Hovering Flight

An automatic attitude stabilization system for a typical hovering helicopter [see Appendix (I)] was first considered. The system was assumed to change the applied cyclic pitch by an amount proportional to the sum of attitude error and rate of change of attitude. In other words, the system used both rate and proportional error feedback, with the ratio of rate feedback to proportional feedback being unity. The constant of proportionality, or feedback sensitivity, was allowed to vary from zero to a large positive value.

Fig. 2 illustrates the variation of the system roots with changing feedback for an automatic stabilizer servomotor having an infinite natural frequency (a "perfect" servo). The helicopter is represented by the quasi-static rotor assumption method. Note that stable operation is achieved at a very low value of feedback and that increasing the feedback never makes the system unstable again.

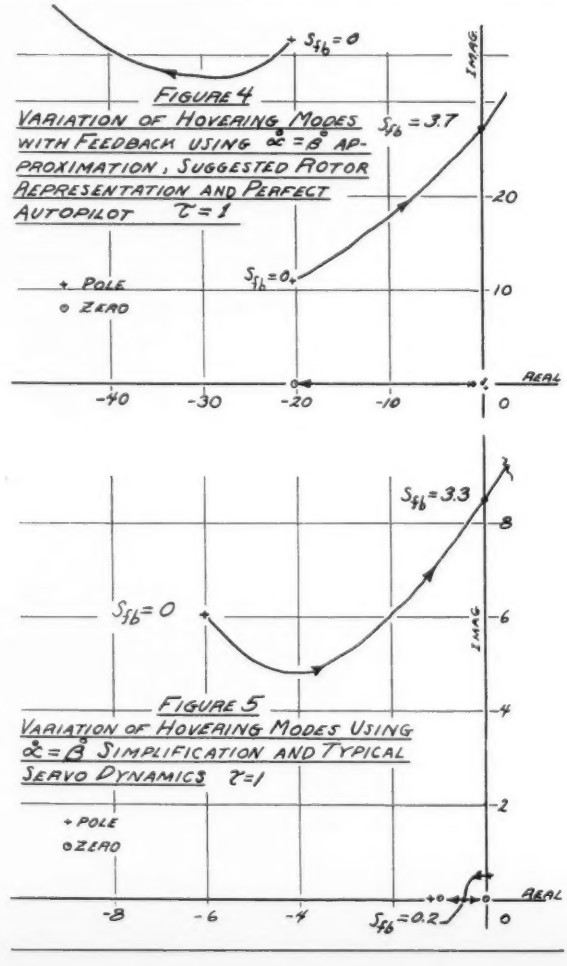


FIGURE 4
VARIATION OF HOVERING MODES WITH FEEDBACK USING α = β APPROXIMATION, SUGGESTED ROTOR REPRESENTATION AND PERFECT AUTOPILOT τ = 1
+ POLE
○ ZERO
IMAG
REAL
FIGURE 5
VARIATION OF HOVERING MODES USING α = β SIMPLIFICATION AND TYPICAL SERVO DYNAMICS τ = 1
+ POLE
○ ZERO
IMAG
REAL

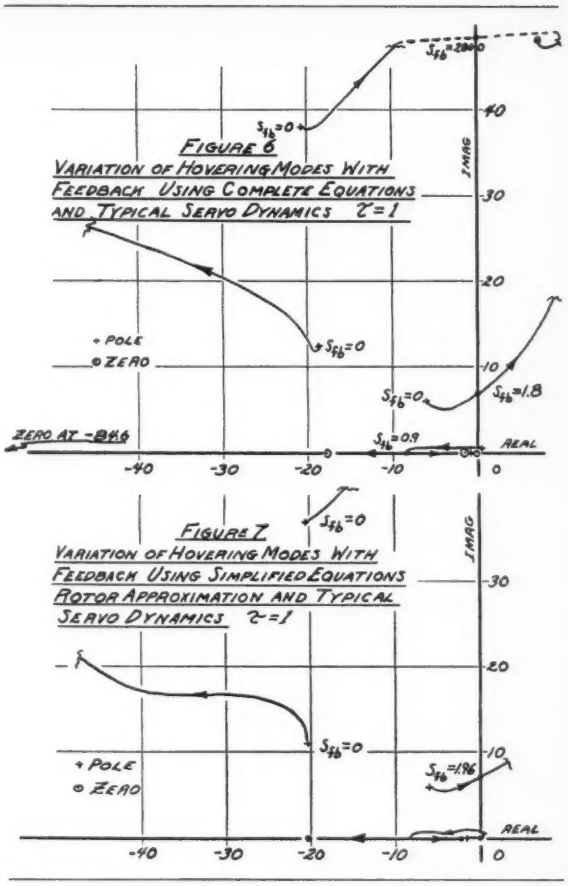


FIGURE 6
VARIATION OF HOVERING MODES WITH FEEDBACK USING COMPLETE EQUATIONS AND TYPICAL SERVO DYNAMICS τ = 1
+ POLE
○ ZERO
ZERO AT −B/A
IMAG
REAL
FIGURE 7
VARIATION OF HOVERING MODES WITH FEEDBACK USING SIMPLIFIED EQUATIONS ROTOR APPROXIMATION AND TYPICAL SERVO DYNAMICS τ = 1
+ POLE
○ ZERO
IMAG
REAL

Fig. 3 shows the locus of roots for a similar system except that the helicopter is represented by equations of motion including rotor dynamics. Unsatisfactory operation occurs at a feedback sensitivity of 4.8 deg. cyclic pitch per degree attitude error. Note that this is an instability that is unpredicted by the quasi-static rotor approximation.

Fig. 4 is the same system except that the helicopter is represented by the suggested approximate method. Unsatisfactory operation occurs at a feedback sensitivity of 3.7. Thus, the approximation appears to give a conservative estimate of trouble-area boundaries.

Since an infinite natural frequency servo is the ultimate high limit for servo design, it now seemed advisable to consider a servo with a natural frequency approaching the lower limits used in aircraft work. The servo dynamics used were those of a second-order, seven-tenths damping ratio servo of natural frequency equal to $8^1/_2$ rad. per sec. These characteristics are approximately those reported by Seamans,[3] for the Minneapolis-Honeywell C-1a Autopilot Servo.

Fig. 5 shows the variation of the system roots when the helicopter is represented by quasi-static rotor methods. Unsatisfactory operation is predicted to occur at a feedback sensitivity of 3.3.

Fig. 6 repeats the study with the helicopter represented by the "complete" equations of motion. Unsatisfactory operation now occurs at a sensitivity of 1.8

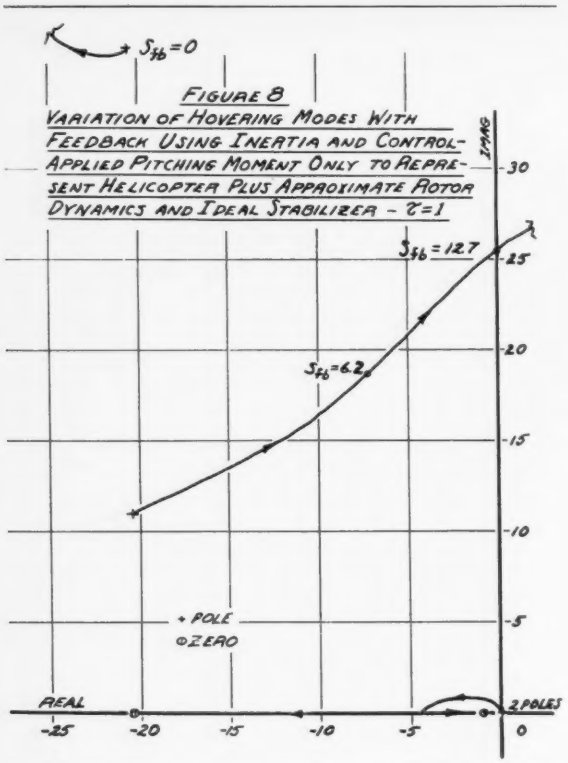


FIGURE 8
VARIATION OF HOVERING MODES WITH FEEDBACK USING INERTIA AND CONTROL-APPLIED PITCHING MOMENT ONLY TO REPRESENT HELICOPTER PLUS APPROXIMATE ROTOR DYNAMICS AND IDEAL STABILIZER - $\tau=1$

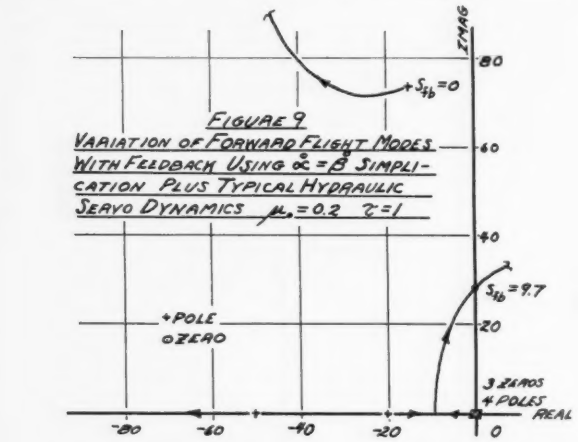


FIGURE 9
VARIATION OF FORWARD FLIGHT MODES WITH FEEDBACK USING $\dot{\alpha}=\beta$ SIMPLICATION PLUS TYPICAL HYDRAULIC SERVO DYNAMICS $\mu_o=0.2$ $\tau=1$

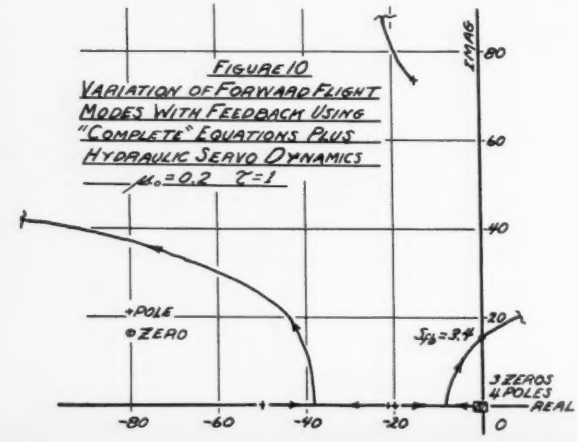


FIGURE 10
VARIATION OF FORWARD FLIGHT MODES WITH FEEDBACK USING "COMPLETE" EQUATIONS PLUS HYDRAULIC SERVO DYNAMICS $\mu_o=0.2$ $\tau=1$

deg. per deg. Since this is a neutral stability condition one may infer that the proposed maximum feedback of 1.5 would be dangerously close to unsatisfactory operation in this system and that consideration of rotor dynamics would be a desirable feature of a control analysis of this system.

Fig. 7 is a check on the validity of the rotor dynamics approximation. Unsatisfactory operation occurs at a feedback of 1.96, extremely close to the value predicted by the complete equations.

It has been indicated by R. H. Miller that a good approximation to the initial helicopter transient response may be obtained using only the helicopter derivatives corresponding to pitching moment of inertia and cyclic control-developed pitching moment. Fig. 8 shows the variation of system roots with attitude error and rate feedback when the helicopter is represented by this inertia approximation combined with the suggested rotor approximations. Comparison with Fig. 3 indicates that while Miller's method is adequate for preliminary design work, it is an unconservative method for detailed analytical work.

(B) *Forward Flight*

A similar set of studies was made for the same helicopter in forward flight. The same stabilization system was used, except that the servo was represented by the dynamics of a very good hydraulic servo.

Fig. 9 is the locus of roots for this stabilized helicopter considering the helicopter represented by quasi-static rotor techniques. Instability occurs at a feedback of 9.7, well beyond the desired operating area.

But, when rotor dynamics are introduced as in Fig. 10, predicted instability feedback is 3.4 deg. per deg. Fig. 11, which considers rotor dynamics by the approximate technique, gives a conservative estimate of 3.0 as the unsatisfactory operating feedback boundary.

(C) *Summary of Theoretical Results*

(1) Neglecting rotor dynamics in an analysis of a high feedback gain attitude stabilizer may lead to a false sense of security concerning system capabilities.

(2) Presence of rotor dynamics requires either that maximum feedback be considerably limited for any given real servo or that a better (i.e., higher natural frequency) servo than indicated by quasi-static rotor equations be used to attain satisfactory operation at any given high feedback gain.

(3) Use of the suggested rotor dynamics approximation appears to be a conservative and reasonable method of simplifying the consideration of rotor dynamic effects.

(VII) Experimental Results

(A) *Model Tests*

The experimental work at M.I.T. was carried out on a dynamically mounted test specimen. The model was gimbal-mounted at the end of a rotating cantilever

beam, obtaining in this manner pitching and translational freedom but no vertical freedom. Since the model was tested at hover only, this lack of vertical freedom agreed with the conditions of the equations of motion. Fig. 12 is a photo of the model and mount.

The test rig consisted of two coaxial two-bladed rotors, constructed with both flapping and drag hinges, as well as feathering hinges. Cyclic control was of the conventional swash plate variety, with the swash plate electrically controlled from a remotely located control position. Power was supplied by a $^1/_2$-hp. electric drill motor.

The model in operation exhibited typical hovering helicopter characteristics, having an oscillation at 0.6 rad. per sec. Considerable skill on the part of the operator was required to "fly" the model.

Theoretical equations predicted the instability to occur at 0.7 rad. per sec.

Two techniques for obtaining the dynamics, or frequency response, of the model were available. A steady sinusoidal excitation could be applied; after the transient disappeared, the amplitude and phase angle could be measured. However, the transient of the unstabilized model never disappears. Hence a successful application of this method requires that some stabilization be applied to the helicopter to restrict the transient.

It was also found that the methods developed by Dr. Seamans[4] for extracting frequency response data from

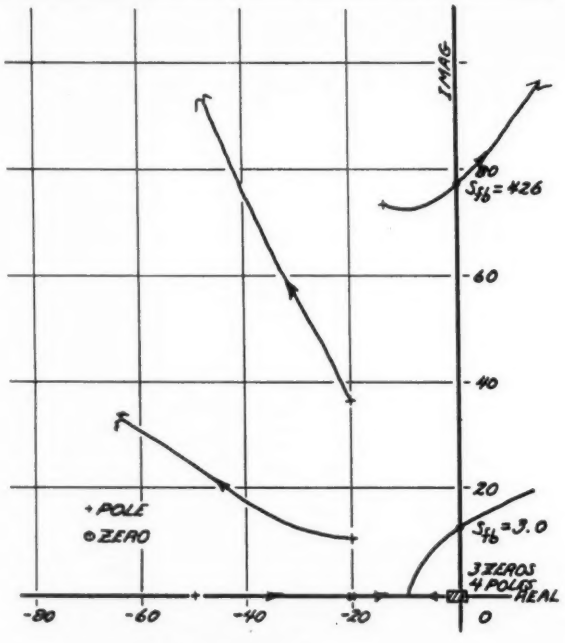


FIGURE 11
VARIATION OF FORWARD FLIGHT MODES WITH FEEDBACK USING $\alpha = \beta$ SIMPLIFICATION, APPROXIMATE ROTOR DYNAMICS AND HYDRAULIC SERVO DYNAMICS
$\mu_0 = 0.2 \quad \tau = 1$

FIGURE 12
MODEL ON SWINGING ARM MOUNT

transient responses to pulse-type inputs could be applied to unstable systems provided that two conditions could be fulfilled. It should first be possible to maintain the system in an equilibrium condition, and it must be possible to record enough of the unstable oscillation following a pulse input so that a satisfactory analytical expression for the oscillatory transient can be determined.

It was originally intended to apply this method to the measurements of model dynamics. However, it was found that neither of the above conditions could be satisfactorily met.

It was therefore necessary to construct a simple automatic stabilizer for the model. A pitch error signal from the gimbal bearing was combined with a rate of pitch signal from a rate gyro, and the resulting stabilization control added to the control stand input. This system operated satisfactorily; it is interesting to note that the roots locus method predicted instability boundaries within 15 per cent.

Having stabilized the system, either test method could be satisfactorily applied for dynamic measurements. For sinusoidal operation the stick was mechanically oscillated at various frequencies. The automatic stabilizer introduced sufficient amplitude and

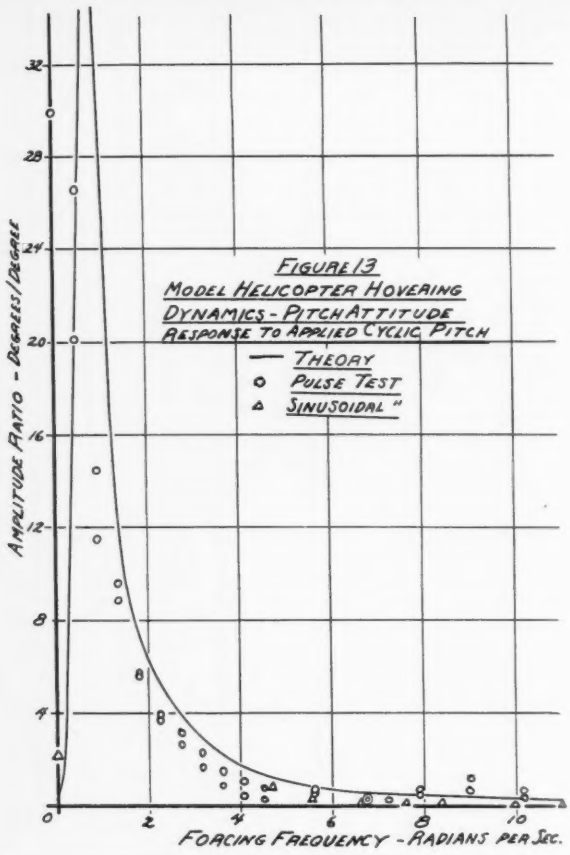


FIGURE 13
MODEL HELICOPTER HOVERING DYNAMICS - PITCH ATTITUDE RESPONSE TO APPLIED CYCLIC PITCH

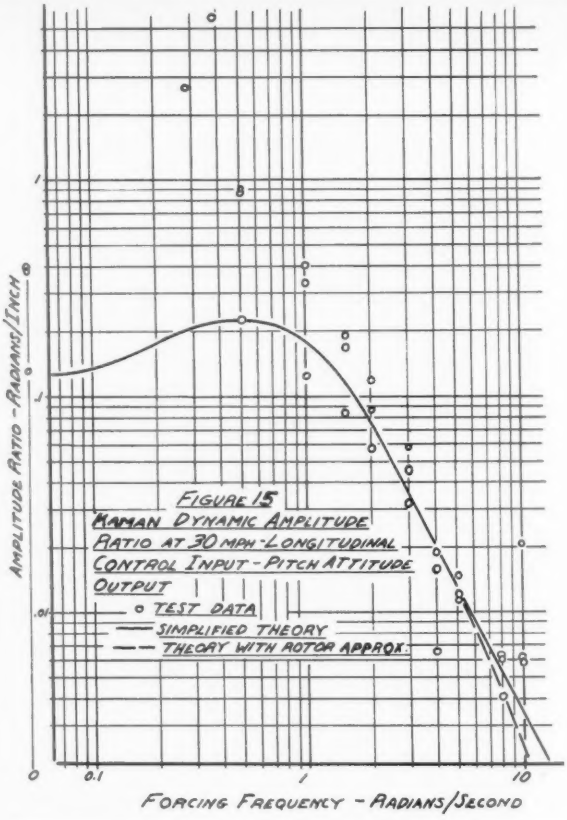


FIGURE 15
KAMAN DYNAMIC AMPLITUDE RATIO AT 30 MPH - LONGITUDINAL CONTROL INPUT - PITCH ATTITUDE OUTPUT

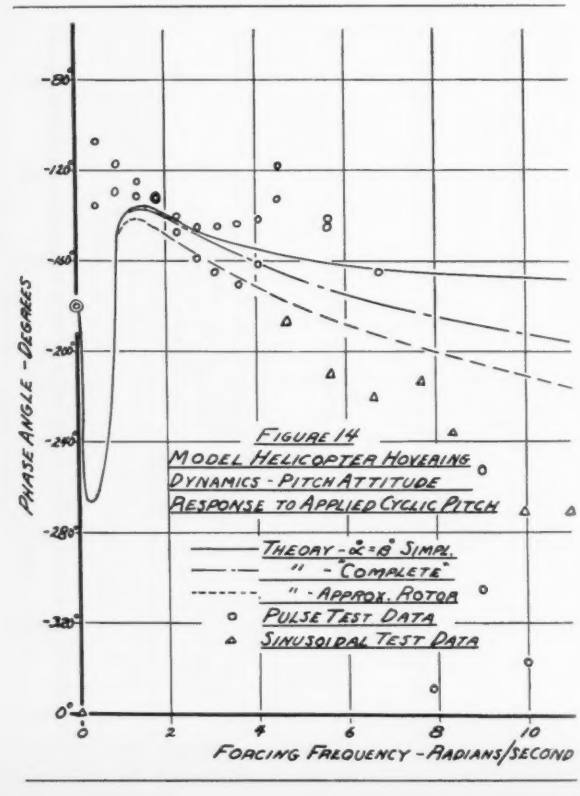


FIGURE 14
MODEL HELICOPTER HOVERING DYNAMICS - PITCH ATTITUDE RESPONSE TO APPLIED CYCLIC PITCH

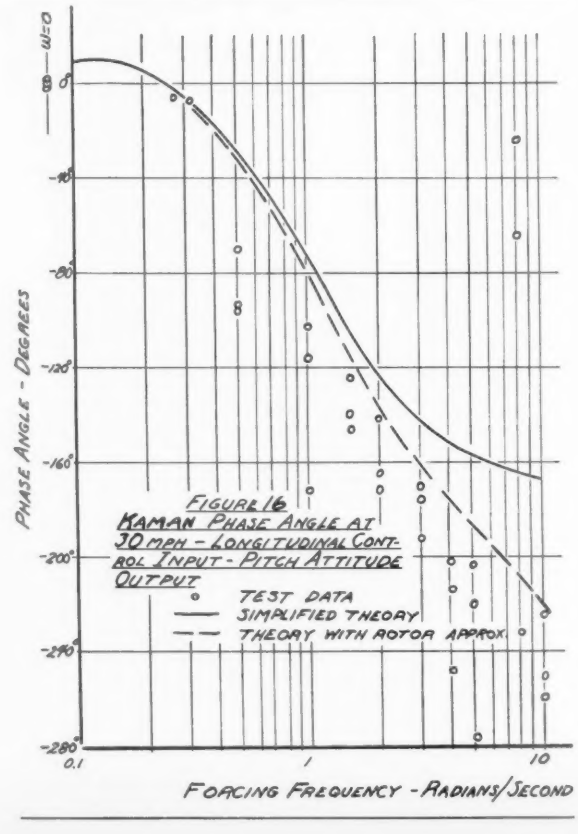


FIGURE 16
KAMAN PHASE ANGLE AT 30 MPH - LONGITUDINAL CONTROL INPUT - PITCH ATTITUDE OUTPUT

phase shift to maintain the helicopter in equilibrium. The dynamic response was determined by recording swash plate input and pitch attitude output. Note that this excludes any necessity for removing stabilizer dynamics from the test data.

A similar technique was used for pulse-type inputs.

Fig. 13 is a comparison of theoretically predicted and experimentally measured model dynamic amplitude ratio versus forcing frequency of the input. Fig. 14 presents theoretical and experimental phase angles. Both are displayed for cyclic pitch input and attitude output. Theoretical responses were calculated by the methods of reference 1, using the model characteristics tabulated in Appendix (II). Experimental responses were measured by both pulse and sinusoidal inputs.

Fig. 13 is seen to indicate a reasonable degree of success in predicting amplitudes of motion. As might be expected, Fig. 14 shows more scatter in phase angles of resulting motion. However, a definite trend toward lagging phase angles greater than 180° is indicated for forcing frequencies approaching 10 rad. per sec. The quasi-static rotor method does not predict this trend; the approximate method seems to be reasonably successful in doing so. As indicated by the theoretical studies, failure to consider these dynamics may result in dangerous simplification.

(B) Full-Scale Kaman Tests

The Bureau of Aeronautics of the U.S. Navy has made it possible to include in this report the results of experimental and theoretical determination of the power-on longitudinal dynamic characteristics of a Kaman helicopter. Figs. 15 and 16 display the information gathered in this investigation.

The transient analysis or pulse-type input method of dynamic flight testing was used at Kaman. The data were reduced by punched-card computer techniques, using the approximation method outlined by Dr. Seamans.[4] At all the test speeds except hover, the Kaman exhibits positive dynamic stability; hence, the techniques suggested by Seamans for the analysis of lightly damped oscillatory systems could be directly applied. At hovering, the Kaman has the oscillatory divergence characteristics common to present-day helicopters. However, this divergence is so slow that it was possible to completely trim the machine, apply a sizable control input, and record several cycles of the resulting oscillation before the pilot was forced to recover. The frequency and damping ratio of the oscillatory response could then be determined, and the methods outlined by Seamans for lightly damped systems applied to the data.

Some confusion originally existed as to the validity of extending Seamans' method to systems with negative damping—i.e., divergently oscillatory systems. Reference 4 does not sufficiently emphasize the fact that the performance or transfer function is the ratio of the Laplace transforms of output and input. In the discussion concerning lightly damped systems, the Fourier transform is emphasized; the two types of transformations yield similar results for sinusoidal excitations of stable systems. However, the Fourier transform of an unstable oscillation does not exist, while the Laplace transform does. Hence, a casual reading of reference 4 tends to suggest that only lightly damped stable systems may be so treated. It is once again emphasized that such is not the case and that the method is satisfactory for slightly unstable systems.

Rotor speed was recorded during the pulse-type maneuvers. The recording system used gave an estimated overall resolution of 1 per cent of rotor speed. None of the pulse-type records exhibited any discernible variation of rotor speed. This feature of the pulse-type input is particularly desirable for theoretical-experimental comparisons, since the theoretical analyses were made assuming constant rotor speed.

The theoretical dynamics of the Kaman were obtained by extending the methods of reference 1 to the servo flap type of rotor control. This necessitated the introduction of suitable terms to account for the variation of servo flap angle of attack and, hence, blade pitch angle, with rotor inflow and flapping. Dynamic performance functions were calculated using the quasi-static rotor approximations and then modified as suggested herein to account for rotor dynamics. The modifying expression included both the rotor tip-path plane dynamics and the servo flap-blade torsion dynamics.

Fig. 15 displays the dynamic longitudinal amplitude ratio versus forcing frequency at 30 m.p.h. air speed. Fig. 16 displays the corresponding phase angle.

Examination of the phase angles bears out the conclusions that rotor dynamics should be included in a high-feedback system and that the suggested approximation to rotor dynamics is a satisfactory approximation.

Examination of amplitude data seems to indicate reasonably repeatable data at frequencies above $^1/_2$ rad. per sec., but considerable scatter is evident at lower frequencies. So many external sources of low-frequency excitation are present that this is not at all surprising. Atmospheric turbulence, power changes, and recording uncertainties appear to limit the validity of such data. However, this region is not of great interest to the autopilot designer and the low-frequency gap may be filled satisfactorily by the extrapolation of static stick position-fuselage attitude data.

(VIII) Conclusions

Five conclusions appear justified by the results of the preceding investigations.

(1) Analytical consideration of high-feedback helicopter automatic control systems should include a consideration of rotor dynamics.

(2) Computations required for such consideration may be considerably reduced by considering the rotor

dynamics and the helicopter dynamics as two cascaded systems.

(3) Experimental data indicate this assumption to be valid.

(4) Transient analysis techniques of frequency response measurements, using pulse-type inputs, are satisfactory when applied to helicopter dynamic stability measurements.

(5) The presence of rotor dynamics requires one of two modifications to a system designed by neglecting the rotor. For a given servo, unsatisfactory operation occurs at a lower value of feedback; or, for a satisfactory system at a particular value of feedback, a better servo performance is required.

References

[1] Miller, R. H., *Helicopter Control and Stability in Hovering Flight*, Journal of the Aeronautical Sciences, Vol. 15, No. 8, p. 453, August, 1948.

[2] Bollay, Wm., *Aerodynamic Stability and Automatic Control*, Journal of the Aeronautical Sciences, Vol. 18, No. 9, p. 569, September, 1951.

[3] Seamans, R. C., et al., *Application of the Performance Operator to Aircraft Automatic Control*, Journal of the Aeronautical Sciences, Vol. 15, No. 9, p. 535, September, 1948.

[4] Seamans, R. C., et al., *The Pulse Method for the Determination of Aircraft Dynamic Performance*, Journal of the Aeronautical Sciences, Vol. 17, No. 1, p. 22, January, 1950.

Appendix (I)—Characteristics of Typical Helicopter

G.W.	= 2,560 lbs.
S	= disc area = 1,134 sq.ft.
Ω	= 23.7 rad. per sec., R = 19 ft., ΩR = 450 ft. per sec.
I_p	= 2,560 slug-ft.^{2}
h	= 4.75 ft., σ = 0.06, n = 3
m_b	= 1.65 slugs per blade, d = 7.6 ft.
e	= 0.57 ft.
C_{d_0}	= 0.012
a_0	= 6.0
f/s	= fuselage drag = 0.0174
$dC_m/d\alpha$	= fuselage moment slope = −0.0026 per rad.
I_b	= blade inertia = 186 slug-ft.^{2}

Appendix (II)—Characteristics of Model Helicopter

G.W.	= 17 lbs.
I_p	= 0.523 slug-ft.^{2}
h	= 1.7 ft.
Ω	= 41.8 rad. per sec., R = 2.5 ft.
I_{Arm}	= moment of inertia of support arm = 14.05 slug-ft.^{2}
D_{Arm}	= viscous drag of arm as seen at model = $0.0076V$
m_b	= 0.0122 slug, n = 2 blades/rotor, 2 rotors
e	= 0.094 ft.
d	= 0.96 ft.
I_b	= 0.020 slug-ft.^{2} per blade
θ_0	= 10°
C_{D_0}	= equivalent blade profile drag = 0.041
a_0	= 5.02
σ	= 0.063
T	= thrust = 5.26 lbs. at 400 r.p.m. or 8.36 lbs. at 500 r.p.m.

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Military Air Cargo Carrier Trends*

WALTER TYDON†
Fairchild Engine and Airplane Corporation

Introduction

World War II gave military air cargo its real start. It took, however, an episode like the Berlin Airlift to accentuate the need for large-scale operation and the Korean Airlift to give it full recognition by both the military and public. Today, with the scope of American defense world wide, there is correspondingly increased emphasis on the air cargo carrier. The paramount importance of military air transportation, offering as it does the maximum in flexibility and dispersal of material, has been amply pointed up in lessons of the past—that fixed defenses can be bypassed, as the Germans went around the Maginot Line and as we by-passed the fortified islands of the Pacific—and by the advent of the atomic bomb, which prohibits, for the future, large ground concentrations.

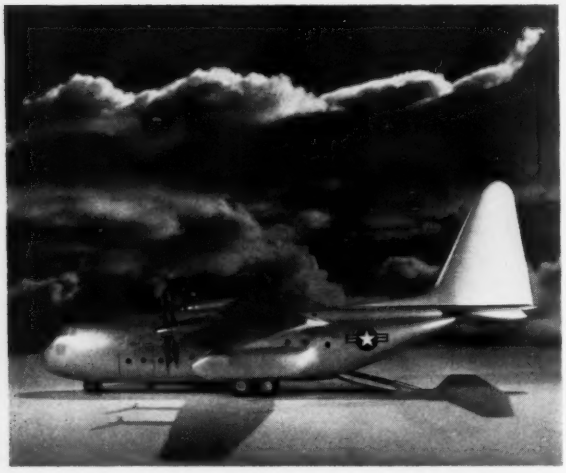
Our military air cargo operations, until 10 years ago, relied upon converted passenger types for their airplane equipment. The only true military cargo carrier in production today, designed for the specific purpose of carrying military cargo, is the C-119. The C-119 is scheduled to be supplemented by the C-123 and the C-130, types also designed specifically for hauling military cargo.

This 10-year period has provided us with many lessons that have had to be learned and has given us a clearer picture of the trends that, in its expanding

Presented at the Aircraft Design Session, Twenty-First Annual Meeting, IAS, New York, January 26–29, 1953.

* This paper does not attempt to define trends in the configuration of the aircraft of the future but rather the operational trends and their effect on the design of components and systems. The conclusions reached are derived mainly from contacts with air cargo carrier activities and the experiences gained from the Fairchild C-82, C-119, and XC-120 airplanes and, therefore, are not necessarily the opinion of the rest of the industry. Because Fairchild Engine and Airplane Corporation is not active in the helicopter field and, therefore, is not close to the present applications of helicopters, it has been omitted from this paper. I do not, however, discount the helicopter's place in military air cargo transportation; it has a very important one.

† Chief Engineer, Fairchild Aircraft Division.



Lockheed C-130 turboprop transport design.

scope, military air cargo transportation is taking. Two rather surprising factors come up repeatedly:

(1) There is as ever widening a gap between the conventional-type passenger carrier as we know it today and the military air cargo carrier as there is between a bus and a truck or between a railroad boxcar and coach.

(2) The trends constantly revert to parallels in highway, rail, and marine transportation. In these fields of transport, differences between freight and passenger carriers as to speed and provisions for loading and unloading early showed the need for separate and distinct types, such as the truck vs. the bus, the freight train vs. the limited, and the freighter vs. the liner. Within the cargo category is the well-precedented need for carriers designed for specific purposes—the transportation of liquids, bulk materials, foodstuffs, vehicles, etc. We no longer can pay the multiple penalties of excessive weight, slow loading, and high cost for an all-purpose airplane. Even the railroads, to which weight is of relatively little importance, do not attempt to combine a coal car, a box car, a cattle car, and a passenger car.

A discussion of specific trends in military air cargo transportation follows.

(A) Speed

Air transportation is so much faster than the sequence of surface transportation consisting of truck, rail, ship, rail again, and truck again that efficiency, basically, should govern the cruise speed. A practical measure of speed would be how long a period it would take a given number of airplanes to transport, say, one armored division a given distance. In such an operation we find that airplane speed is only one of the factors involved. Turn-around time is a factor as important as cruise speed. Obviously, another factor is how close to the destination the division can be landed. If the division is needed in Sumatra, landing in Singapore is not good enough.

The jet engine has stretched the rubber band from minimum speed to top speed considerably tighter so that the designer is having difficulty maintaining good flight characteristics, particularly stability and control, at both ends of the speed range. There is naturally a trend to follow jet philosophy to a degree on nonjet types. This trend is leading to a "hotter" airplane in the landing configuration. The majority of accidents occur in landings and take-offs. Couple a "hotter" airplane with a shorter field and you are bound to have an increase in the accident rate. For short fields, a slower flying airplane is mandatory for safety. Similarly, where paratroops and cargo are to be dropped, a slower drop speed is desirable, and in this case, where low-speed formation flight must be maintained, there is special need for excellent stall characteristics and good stability and control with one engine out. For these reasons, the attainment of satisfactory low speeds appears to be of greater importance currently in cargo airplanes than the attainment of high speed.

(B) General Categories of Military Air Cargo Carriers

In spite of efforts in the direction of single-purpose design, hard realities still require that the air cargo carrier of the immediate future be designed for a multiplicity of purposes. It quite naturally becomes the problem of the designer not to sacrifice too much weight for any of these purposes, so that a cumulative effect does not render the airplane inefficient. There is a great danger in this. I believe that the subject carriers can, for convenience, be classified by type and also by mission as follows:

(1) *The Long-Range or Heavy Transport.*—This type operates, say, from the United States to Japan, using permanent airfields at both ends.

(2) *The Medium-Range or Medium-Weight Transport.*—This operates, say, from Japan to Korea, sometimes landing on advance bases or improvised strips.

The long-range airplane will ordinarily not attempt to deliver its cargo to the final destination. The medium-range airplane, however, will in many cases do so by aerial delivery and, to an increased extent, by advance-base and assault-type landings. By degrees we may expect the final stage of the trip, now often a matter of ground transportation, to be shifted to the air.

The missions in which the two main types of air cargo carrier are employed are as follows: (1) normal cargo carrier (vehicles and bulk); (2) personnel carrier; (3) troop carrier; (4) aerial delivery of paratroopers; (5) aerial delivery of resupply and equipment by parachute; (6) air, advance-base or assault landings; (7) litter evacuation; and (8) air rescue.

Certain of these missions, such as assault landings, have up to now been restricted to the medium-weight category.

(C) Fuselage Design

The fuselage becomes rather complicated when the types of carrier and their missions are considered from the standpoint of the following design factors:

(1) Concentrated loading (vehicles, floor tie-downs).
(2) Distributed loading (bulk cargo, floor tie-downs).
(3) Resupply aerial delivery (floor rollers and mechanisms).
(4) Heavy drops (conveyors, floor rollers, and extraction mechanism).
(5) Litter evacuation (used mainly for return trips and requiring posts and attachments).
(6) Troops or paratroopers (seats, anchor cables).
(7) Special containers for such entire units as radar and radio stations.

Vehicles constitute the largest single factor affecting the overall airplane design. The Army in its *Technical Manual TM9-2800* lists over 400 different types of vehicles, which break down by weight as follows: up to 10,000 lbs., 203 vehicles; 10,000 to 20,000 lbs., 112 vehicles; and 20,000 lbs. and over, 91 vehicles.

The dimensions of these vehicles complicate the picture to such an extent that they become a study in themselves. To the vehicles can be added bulk cargo, litter evacuation for return trips, and special items such as jet engines, on which emphasis is currently placed in an effort to shorten the long pipeline of spares.

The smallest cargo compartment specified in active Air Force requirements is 92 in. wide, 78 in. high, and 35 ft. long. These requirements also establish a maximum floor height of 50 in. from the ground. Although there are many who disagree with the low floor, it should be remembered that there are too many trucks and too many truck facilities for the relatively few aircraft to effect a change in the limited and long standard range of truck floor-bed heights. In this connection it is well to remember also that military air cargo carriers must incorporate integral ramps, which, being part of the airplane weight empty, should be kept as low and short as possible.

The floor of the medium-category cargo carrier must be designed for 13,000 lbs. single axle loads or for treadways capable of supporting 120 lbs. per sq.in. The remainder of the floor, for bulk cargo, is adequately designed for 200 lbs. per sq.ft. The Air Force requires that 10,000 lbs. capacity floor tie-down fittings on a 20-in. grid pattern also be included. To further complicate floor design, military cargo operations demand that additional cargo be substituted for fuel, where the distance to be flown is short. In striving for a solution to the floor structural problem, designers have on occasion looked enviously at the construction engineer and his concrete mixer.

The low floor and end loading of the medium-range cargo airplanes have resulted in high-wing configurations. The high wing has presented some problems, but none is too serious. Recently the Air Force has proposed a requirement to strengthen the fuselage in crash landings with the following combined load factors on the bottom of the fuselage: vertically, 4.5*g*; sidewise, 1.5*g*; and aft, 8.0*g*. This requirement is now being incorporated in design. Admitted that the low-wing aircraft offers greater structural protection, the high-wing aircraft nevertheless offers an important feature that has been overlooked by many—greater safety from fire. The high wing, with its fuel and power plants, is not so susceptible to damage in crash landings, and the probability of fire is therefore substantially decreased. In addition, the greatly lessened damage in minor crashes and gear-up landings also goes far in offsetting such disadvantages as the high wing may have.

(D) Aerial Delivery

Aerial delivery is one of the most important forms used in military air cargo transportation. Under certain weather and terrain conditions, it has no substitute. Zero visibility conditions as in the Battle of the Bulge, night resupply missions, and drops over terrain such as Korea or the jungles of Malaya are some examples of its optimum application.

Today finds the paratainer bundle outmoded, the trend being toward larger bundles and larger unit drops. The two most extensively used types at present are the resupply bundle and the heavy, or palletized, drop.

The resupply bundle may weigh slightly over 2,000 lbs. A series of these is normally jettisoned out of the aft end of the carrier by gravity as the airplane is pulled up to a high angle of attack. Static lines, attached to an anchor cable, release the parachute for each bundle.

The heavy drop, usually a vehicle or large-caliber gun, but sometimes a section of a bridge or other structure, has been successfully demonstrated up to 21,000 lbs. Such a drop requires special equipment and a great deal more preparation than the resupply bundle. A pallet is required to support the load and absorb part of the energy of impact. The vehicle or other load is mounted on the pallet with suitable tie-downs and with shock-absorbing pads between its vital parts and the pallet. The main parachute or parachutes are secured to the pallet and, with the pilot and extraction chutes, are carried on the palletized load. The loaded pallet then requires a special handling vehicle, such as the "Traveloader," to raise it off the ground, transport it to the airplane, and load it into position. The heavy drop is extracted from the airplane by an extraction ribbon chute that automatically disengages when the main chute or chutes open. The extraction chute serves two purposes—to extract the load and to keep it from tumbling. One of the limiting factors in this operation is the effect on the aerodynamic control of the airplane as its center of gravity moves aft during the extraction process.

There are many problems still to be worked out in aerial delivery: Parachutes do malfunction on occasion, and high ground winds cause the parachutes to tip pallets over and to drag the loads over the ground. The parachutes, extraction mechanisms, rollers, shock-absorbing devices, and pallets constitute an excessively high tare weight and in the aggregate are too complicated. Preparation of the palletized load consumes too much time. There is also the need for improved

accuracy of drops; for example, just as it is important for a bomber to make a direct hit to destroy a bridge, so it is equally important, to rebuild the bridge, for the military air cargo carrier to deliver a new section by parachute right on the river bank, not in the river and not too far from it.

In personnel transport operation at relatively high altitudes, there is no urgent need for a special emergency exit for rapid crew egress. In aerial delivery missions, however, paratroop drops at 800 ft. and equipment drops at 1,200 ft. make the problem of emergency escape for the crew a critical matter. In most cases, egress must be made from the aft end of the cargo compartment.

As was demonstrated in World War II in the paratroop drops along the Rhine where crew losses were excessive, such egress is not practical, particularly over tied-down cargo, and is extremely hazardous in night operations. The solution to this problem is a crew bail-out chute located in the crew compartment. Such a chute is now a recognized feature of the air cargo carrier.

(E) Advance-Base Operation

Advance-base operation has been referred to as assault landing or air landing. It is a somewhat cloudy subject, encompassing to a degree the now obsolescent World War II glider concept. In all probability, the most controversial item on this subject is the definition of the landing strip as to length, width, and nature of surface. Be this as it may, advance-base operation must be considered as another specialized and highly important form of military air cargo transportation.

While this operation can be employed on any reasonable terrain to deliver cargo close to the front or where combat concentrations prohibit the use of prepared airfields or runways, it is readily apparent that the operation would be more feasible and effective in theaters such as the desert of Sahara, the steppes of Russia, the pampas of Argentina, or the lowlands of Europe. In such areas aerial delivery, with the complication, weight, and cost of parachutes and palletization and with the restrictions imposed by ground wind, does not appear to be as efficient a technique as advance-base operation.

The advance-base air cargo carrier must incorporate a number of special features in order to ensure full utility and preclude difficulties akin to those experienced with our gliders during the last war. It may even be that the Helioplane type of fixed-wing airplane, or the convertiplane or the helicopter, will ultimately take over this field. Reviewing these special features we list:

(1) *Short Take-Off and Landing Distances.*—These are obviously mandatory. Special devices such as boundary-layer control, JATO, and drogue chutes are being considered to further this requirement.

(2) *Exceptional Stability and Control over the Range of Low Speeds Required.*—Here consideration must be given to the loss of an engine due to enemy action, since, with loss of control over a small landing strip, many fighting men and several aircraft would be jeopardized.

(3) *Low Vulnerability.*—Incorporation of passive protection against small-arms fire for vital parts of the airplane, such as power plants and fuel and oil system, is necessary. Similarly, a dual arrangement of such unprotected parts as wheels and tires is necessary.

(4) *Rough-Field Gear.*—The alighting gear visualized is nothing but the application of the conventional tail-wheel principle to all three gears, with the following few additional features:

(a) *The lever-suspension-type gear:* This allows the oleo strut to be universally mounted, thereby permitting the maximum absorption of loads because of the elimination of bending. Long oleo travel is readily available with this arrangement.

(b) *Large diameter wheels:* These obviously facilitate obstacle clearance.

(c) *Low footprint pressure:* This is necessary for operation on "soft" fields having a low subsoil K modulus.

(d) *Ample rubber between wheel rim and rolling radius:* This rubber is the only means of absorbing loads imposed by obstacles when aircraft speeds approach the maximum for take-off and landing, when the inertia of wheels, tires, oleos, etc., is too great for displacement to take place.

(5) *Low Turn-Around Time.*—This is important in all phases of military air cargo transportation, whether in a Berlin Airlift or in a normal supply operation between domestic bases. The importance of low turn-around time reaches its peak in advance-base operation, where the strip or airhead may be under enemy fire. Turn-around time reflects the number of trips possible. A few of the design features that affect it are:

(a) *Intergral ramps:* With commercial air lines using integral passenger stairs, it is not surprising that integral ramps are a must.

(b) *Improved c.g. and weight control in loading:* One of the biggest delays in the turn-around is the current method of loading. Tactical aircraft such as fighters and bombers have predetermined, fixed locations for guns, ammunition, bombs, and other items of useful load. Their c.g. and weight, therefore, are confined to definite limits. This is also generally true of personnel carriers. Military air cargo carriers, however, present a much more complicated loading problem, not only in that cargo may often be of a conglomerate nature but also in that cargo compartment size allows great flexibility in cargo location. It becomes readily possible, therefore, for cargo to be loaded so as to place the c.g. outside the permissible aerodynamic limits.

Simplified methods of determining weight and center of gravity location during loading have be-

come highly desirable, if not mandatory. The current method of determining the weight of each cargo item and loading it in a position determined with the load adjuster leaves much to be desired. Under combat conditions weighing equipment may not be available, and time may not permit this sort of procedure.

Oleo struts have often been considered as a means of readily determining aircraft weight and c.g., but the bending in the conventional oleo strut introduces unacceptable inaccuracies. Elimination of this bending by mounting the oleo strut between universals, would result in a strut on which a pressure proportional to load could be read, as in the static test laboratory, and with which both gross weight and airplane c.g. could be readily determined. Fuel and oil would of course be accounted for, as well as cargo.

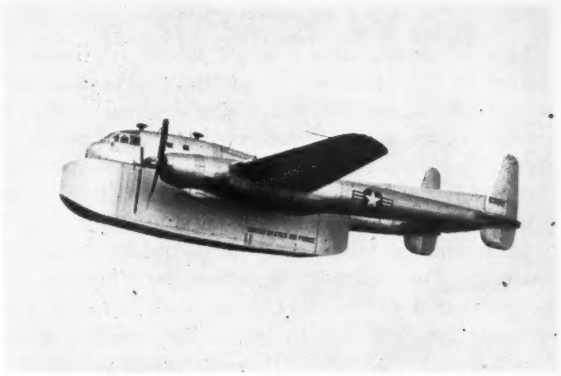
The rough-field-type landing gear, utilizing lever suspension, permits the oleo struts to be universally mounted.

A single chart of nose-gear oleo pressure plotted against main-gear oleo pressures, entered with observed gage readings, indicates at a glance the gross weight and c.g. location. This chart can be used by relatively inexperienced personnel. It also offers a final quick check on take-off gross weight and c.g. and with little complication can indicate the initial elevator trim tab setting.

(6) *External Fuel.*—One of the most versatile of design advancements in safety, service and maintenance, and other operational considerations is the use of 100 per cent external fuel, readily possible in air cargo carriers, where the penalty of some speed reduction is not of too great consequence. By external fuel, I refer to single, large, streamlined fuel tanks mounted one below each wing, in the case of the high-wing airplane. Here again, external fuel is applicable to all types of air cargo carrier but appears to offer greatest advantages to the advance-base airplane. I will outline the major ones:

(a) *Reduction of parts:* Fewer fuel tanks, interconnects, pumps, valves, gages, and plumbing not only simplify the fuel system but the wing construction as well, by the elimination of rib cutouts and access doors and panels to tanks, pumps, gages, fillers, interconnects, etc. Optimum structural design of the wing and decreased deflections become possible.

(b) *Saving in weight:* The weight-saving is rather difficult to determine precisely. For a 16,000-lb. fuel load, some 800 lbs. saving is realized through the reduction in number of parts, and some 1,600 lbs. saving results through deletion of the self-sealing fuel cells. For that small fraction of airplanes operating in combat zones, a self-sealing blanket can be provided for each external fuel tank, at a weight of about 400 lbs. per airplane. The apparent weight-saving in this case is thus 2,000 lbs. Against this, however, must be charged a certain amount of additional fuel made necessary by the additional drag of the external tanks.



Fairchild XC-120 with Pallet Pod.

(c) *Wider limits for cargo c.g.:* The external fuel tanks permit the fuel to be located exactly under the aerodynamic center or other desired location, and the fuel load remains at this point throughout the flight. As a result, the fore-and-aft limits within which the cargo must be located are appreciably widened, thereby speeding up loading operations and making the employment of inexperienced personnel safer.

(d) *Simplified service and maintenance:* Inspection or replacement of a tank is simple. Access to fillers, pumps, and gages is possible from the bumper of the fuel truck, without stands for the removal of doors and sections of wing skin.

(e) *Ease of refueling:* The two-point refueling, one filler in each tank, is far less complicated than the single-point refueling system applied to wing tanks. Fillers are readily accessible from the rear bumper of the fuel truck, which is never in the way of other vehicles or operations around the fuselage. Engines can be left running, or started up for checking, during refueling.

(f) *Safety:* Increased safety is a feature not only during ground refueling but particularly in flight under emergency conditions. All fuel except for a reserve of some 30 min. in the sump is dumpable in a matter of seconds. This feature decreases the fire hazard in crash landings and substantially and quickly reduces the weight of the aircraft, increasing one-engine-out performance. Fuel tank leakage cannot seep to ignition sources. The probability and extent of damage to structure if fire occurs are lessened, if not eliminated by the isolation of the tank. If fire occurs, only the tank should be lost. Damage due to small-arms fire from the ground is greatly lessened because of a reduction of about 50 per cent in the projected area of the tanks. The jettisonable fuel feature offers the potential of higher take-off weights, particularly in the case of twin-engined airplanes where single-engined performance limits this weight.

(F) Detachable Pack

The detachable pack concept should not be considered as a form of air cargo transportation in the sense that aerial delivery and advance-base operation are but rather as a development and trend which is applicable to both these forms, in some cases simplifying them and greatly improving ground handling. The detachable pack, or fuselage, carries with it a weight penalty, and on this account it should be employed properly. For example, to transport a vehicle an integral cargo carrier should be used, since it will probably take less time to unload the vehicle than to detach a pack. However, it is interesting to consider that, if a vehicle were to be carried in a detachable pack, the pack would be lowered to the ground for loading and unloading and ramps could be dispensed with at some saving in weight. The detachable pack is employed most efficiently when it can travel all the way from the point of origin of its cargo to the point of final destination, without intermediate stops requiring partial loading and unloading. In its application it must follow to some extent the pioneering of the highway trailer. The resulting advancement of military cargo ground handling should parallel the benefits that the trailer has brought to the trucking industry.

In considering the potentialities and advantages of the detachable pack, I should like to take up the following points:

(1) Ground Handling

A substantial decrease in required ground facilities is made possible by the detachable pack. First, it can be utilized as a storage container. Second, it can be designed to the general dimensions of the highway trailer so that it can utilize truck loading facilities and handling methods. Third, it eliminates in many cases the present transportation of the cargo by truck to the air terminal, unloading and storage at the terminal, reloading from the terminal to the airplane, and the repetition of these transfers at destination. The detachable pack is taken to the origin of the cargo and to its final destination. It can be so employed that in some circumstances the air terminal, with its associated ground handling equipment, is not necessary. Fourth, it eliminates the tie-up of premium airport space during loading and unloading of the airplane and the need for the associated special loading equipment. Fifth, a reduction in the tare weight of individual packaging is possible because of the reduction in handling. Current military tare weight averages between 35 and 40 per cent of the gross cargo load. For large units of cargo, the pack itself can be considered the container. Sixth, it reduces turn-around time, especially in the case of bulk cargo, by permitting loading and unloading to be carried out over a period of time before the arrival of the carrier, or carriers, and after their departure.

(2) Aerial Delivery

The pack can be parachuted either as an entire unit or in segments. The latter procedure may be required for the distribution of aerial delivery loads to different receivers, or for ease in ground handling. The pack simplifies the method of aerial delivery by eliminating the now necessary horizontal movement of the cargo, pallets, and parachutes over the floor rollers during extraction. In other words, the extraction process is eliminated. The accuracy of drops should be improved thereby, as well as the change of airplane trim experienced now as the load goes over the rear sill.

(3) Surface Delivery

By "surface delivery" is meant the release of a loaded pack from the carrier when flying slowly over the drop zone, skimming the ground. This technique has been tested experimentally with large-scale models and appears to be another distinct form of cargo delivery. It is feasible only with the detachable pack. Its application will be to situations where even terrain is available and where time is of the essence, since, with no actual landings made, the operation will enable the deposition of a number of packs in rapid succession. The operation will be especially attractive as an alternative if strong enemy ground fire is anticipated. The pack, released from the carrier in a touch-and-go-type technique, will be equipped with skids incorporating shock struts and with decelerating devices. The concept can be applied over water perhaps even better than over land. The pack for surface drops over water would have to be water tight and might be equipped with hydroskis.

(4) Safety

Jettisoning the detachable pack offers a highly effective, if drastic, method of lightening ship, at least in military service, should an extreme emergency arise such as engine failure after take-off, forced landing in a cramped area, or unexpected difficulty with terrain clearance during flight.

Analysis and Design of Multipost-Stiffened Wings

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ABSTRACT

This paper discusses an unconventional type of wing construction which utilizes spanwise rows of vertical posts to stabilize the compression skin against buckling by tying it to the inherently stable tension skin. Manufacturing advantages are: (1) additional working space gained through the openings between the posts and (2) fewer internal fasteners necessary to attach posts as compared to shear webs. Stringers installed along the lines of posts are needed to achieve high buckling strengths and to prevent an undesirable type of buckling involving both tension and compression skins. However, these stringers need be only one-tenth as stiff as stringers acting alone. Basic concepts that should be understood before design optimization is attempted are explained. Theory recently developed by the NACA is interpreted, and the results of large-scale static tests conducted at Northrop Aircraft, Inc., to substantiate the design of a complete post-stiffened wing are discussed.

SYMBOLS

A	= area of stringer cross section
D	= plate flexural stiffness, $Et^3/12(1-\mu^2)$
D_T/D_C	= plate flexural stiffness ratio
E	= Young's modulus of elasticity of plate or stringer material
EI	= stringer flexural stiffness
EI/lD	= stringer flexural stiffness parameter
F	= axial stiffness of posts, force per unit deflection, EA/h
h	= height of posts
k_x	= plate axial-load coefficient, $N_x l^2/\pi^2 D$
k_{xy}	= plate shear-load coefficient, $N_{xy} l^2/\pi^2 D$
L	= longitudinal distance between posts
l	= transverse distance between posts and edge of cover plate
L/l	= post spacing ratio
N_x	= plate axial load per unit width
N_{xy}	= plate shear load per unit width or length
P_x	= stiffener axial load
S	= post axial stiffness parameter, $Fl^2/\pi^4 D_C$
t	= plate thickness
μ	= Poisson's ratio

Subscripts

C	= compression
T	= tension

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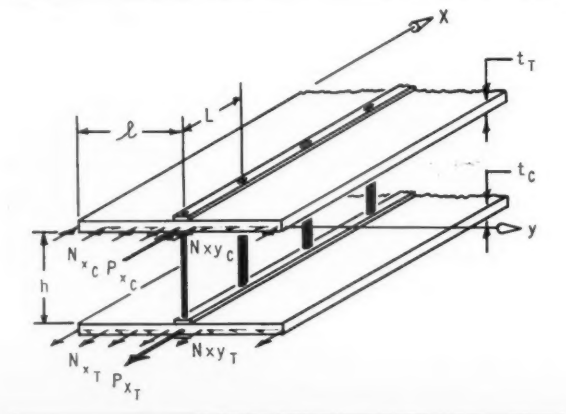
* Group Leader, Structural Research and Development.



(I) INTRODUCTION

SEVERE PRODUCTION PROBLEMS are being encountered by aircraft manufacturers in fabricating thin high-speed wings with heavy skins and many spars. Airfoils are becoming thinner, and internal working spaces are growing continuously smaller; yet strength and stiffness requirements are dictating heavier and, often, more complex internal structure. Accessibility is further reduced by the large-sized cover plates needed to reduce the number of splices in the thick skin and their inherent weight and cost. Unfortunately, final assembly can seldom be accomplished from the outside surface because of the limited variety of flush blind fasteners available with adequate strength. These structural trends mean that assembly problems are becoming increasingly difficult and that workmen must reach farther and perform more operations in confined spaces and under cramped conditions.

The multipost-stiffened wing is a partial answer to these problems in the range of wing thicknesses, wherein a built-up internal structure is still possible but where manufacturing accessibility is at a premium. In this wing, spanwise rows of vertical posts are used to replace alternate spar webs. These posts offer several advantages: (1) Fewer internal connections are necessary; only one fastener is required at each end of each post instead of the two continuous rows of fasteners required to attach a shear web. (2) The open spaces between posts increase accessibility for making installations. (3) The routing of wiring, plumbing, ducts, and other internal equipment is greatly simplified.

These posts are structurally quite efficient, since they stiffen the compression skin against buckling by tying it to the inherently stable tension skin. This efficiency is most easily demonstrated if the posts are assumed to be added to a given structure rather than to be used in place of spar webs. As an example, take the case of adding posts to a long one-cell box beam having longitudinal stringers that provide simple support along the cover centerlines. The addition of posts to tie the upper and lower stringers together makes it possible to reduce the stringer stiffness less than one-tenth of its original value and still achieve the same support for the skin. A post-stringer combination of this type can be

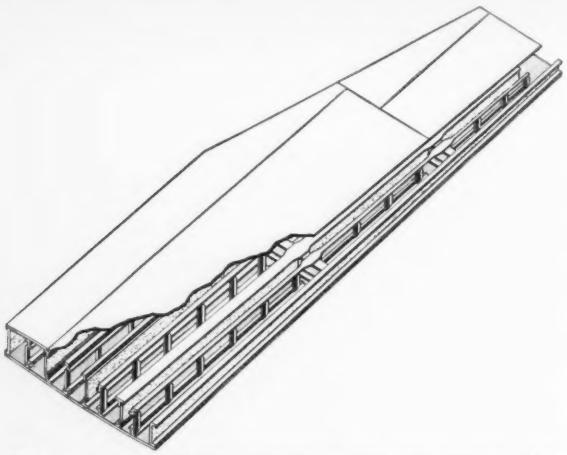


FIG. 1. Cutaway sketch of Northrop multipost-stiffened wing.

equivalent to a spar (under bending loads) if sufficient true spars are nearby to carry the direct shear loads.

The strength analysis of a wing stiffened by posts is not much more difficult than that of a standard multispar or stringer-stiffened wing, provided that the engineer understands the concepts involved and has the necessary design data at hand. He must recognize and know how to evaluate the several possible buckling modes that may involve the simultaneous buckling of both tension and compression skins, as well as the usual buckling of the compression skin alone.

The purpose of this paper is to summarize the present knowledge of some important concepts and relationships which can be useful to the engineer and to point out the available sources of quantitative design criteria. Most of this knowledge has been contributed by Paul Seide and others* at the Structures Research Division of the National Advisory Committee for Aeronautics in solving some of the extremely complex theoretical problems involved and in providing quantitative criteria. Much has also been learned from theoretical studies and experimental testing and from the design of a wing for a high-speed airplane at Northrop Aircraft, Inc. There is much more to learn, but enough is now known to permit practical design with a high degree of assurance.

One further introductory point is in order for the benefit of the historians. The post-stiffened wing is not an invention of the author, nor is it completely new. For many years, airplanes have been flying which have had one or more posts used either as holding devices during fabrication or as additional stiffening devices found necessary (and, incidentally, extremely efficient) by static tests. At least one aircraft manufacturer (Curtiss-Wright Corporation, 1948) recognized the possibilities of the post-stiffened wing to the extent of studying and testing box beams containing a limited number of posts. Only recently, however, have sufficient theoretical criteria and test substantiation been available to justify safe optimum design of structures based on many posts used as primary structural elements.

* See References.

(II) Construction Details

The construction illustrated in Fig. 1 is the main structural box of a wing designed for a modern high-speed interceptor airplane.† This wing has five spars interspaced with four rows of posts which are attached to stringers on the upper and lower covers. The posts are simply short lengths of extruded angle sections attached by one fastener at each end and placed at intervals of 6 to 11 in. apart.

The wing skins exceed $^3/_8$ in. in thickness near the root. The supporting structure for these thick skins is similar to multispar construction, which provides support through closely spaced spars and has very few cordwise ribs. It differs from pure multispar construction in that stringers, in conjunction with posts, are utilized to provide full simple support to the skin in wing bending and, thus, to replace some of the spars. These stringers are used in a design range wherein, if they were required to provide full simple support to the skin with no posts present, they would have to be so large that they would nearly meet at the chord plane.

The maximum airfoil thickness ranges from 5 in. near the tip to 10 in. near the root. This general wing thickness is in the transition range, wherein fully machined spars are sometimes considered as practical as built-up spars. In this wing, the front and rear spars are actually machined one-piece units, but the intermediate spars are assembled from standard type caps and webs.

The ribs are fully machined "I"-section beams, which are placed 105 in. apart on the inboard end of the wing and even farther apart outboard. The resulting aspect ratios of the structural bays are large.

The weight of a conventional multispar wing in this range decreases as it is designed for more spars. How-

† Not currently under construction.

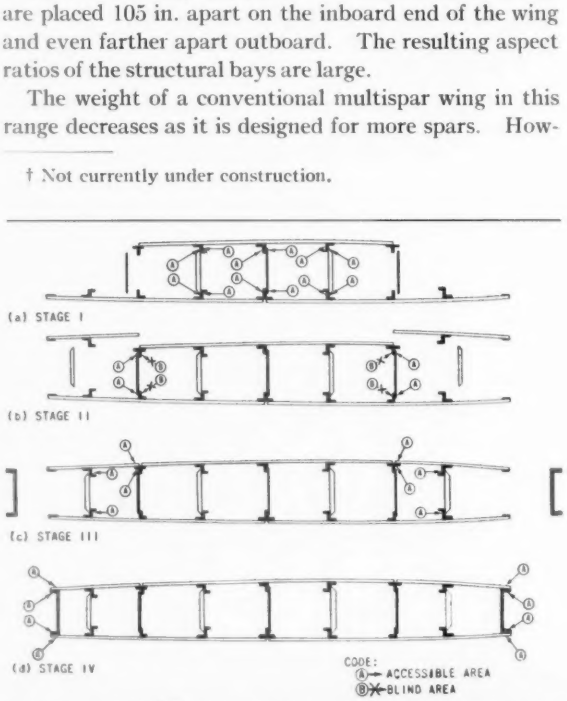


FIG. 2. Assembly procedure for Northrop multipost-stiffened wing.

ever, the cost increases, and manufacturing accessibility decreases so rapidly with increasing numbers of spars that the final design must be a compromise. It is interesting to notice that the weight* of this post-stiffened wing, which is essentially a nine-spar wing, is about the same as a thirteen-spar wing designed without posts or stringers. This weight advantage, however, diminishes if the torsion loads become high compared to the bending loads; therefore, the major advantage of the post-stiffened wing is considered to lie in the greater ease of fabrication rather than in weight-savings.

One assembly procedure proposed for the Northrop wing is shown in Fig. 2 to illustrate some of the manufacturing advantages. This procedure utilizes three basic wide plates that are preformed to contour and to which stringers and spar caps are subassembled. Two of these plates, each of which is 40 in. wide at the root, form the complete bottom skin of the structural box. The third plate, also 40 in. wide at the root, forms part of the top skin and is centered over the middle spar. This arrangement [see Fig. 2(a)] reduces the maximum inside working distance to 20 in., a reasonably comfortable reach for the average worker.

The three basic cover plates are placed in the main assembly jig along with the machined ribs, and the internal structure is then installed as follows: First, the center spar web is inserted in sections between the ribs. This web is accessible from both sides and is easily fastened in place with hole-filling lockbolts. Next, the posts are installed on the second and fourth sets of stringers. These can also be fastened in place with hole-filling lockbolts, because they are accessible from both sides by reaching through the spaces between posts. Then the second and fourth spar webs are installed [Fig. 2(b)]. One side of each of these webs is inaccessible; however, the other side is almost completely in the open, and blind lockbolts can be used to obtain sound joints with a rapid assembly procedure. Finally, the assembly is completed as shown in Figs. 2(c) and 2(d). Two narrow plates complete the top cover; the first and fourth rows of posts are installed in the same manner as the previous posts, and the machined closing spars are inserted and fastened by means of their outward-facing flanges. This assembly procedure, utilizing posts, permits rapid construction with good accessibility at all stages and with a relatively small number of internal connections. The installation and routing of internal equipment such as wiring, plumbing, ducts, etc., is also simplified.

(III) Compressive Buckling Concepts

In order to perform a strength analysis of any structure, it is necessary to know how that structure behaves under load. The post-stiffened wing has some buckling characteristics peculiar unto itself and not found in the conventional multispar or stringer-stiffened wings. The basic concepts of these buckling characteristics

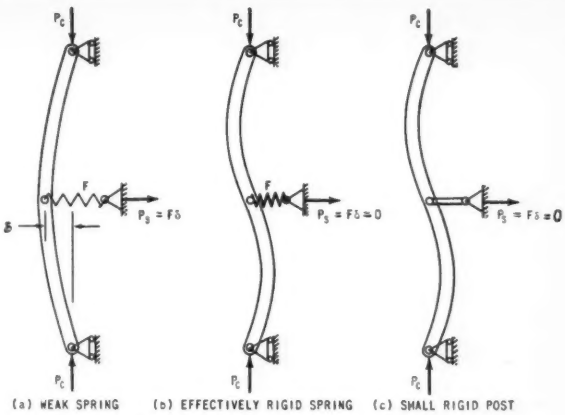


FIG. 3. Buckling modes for spring-stiffened column.

and some pertinent relationships are discussed here to facilitate application of the theory developed by NACA[1, 2, 3] in the strength analysis of practical problems.

For simplicity, the discussions are limited to long beams with one row of posts. All plate edges are assumed to be simply supported. When stringers are mentioned, it is implied that identical stringers are used on both plates, regardless of the relative plate thicknesses and that only one stringer is placed on each plate along the line of the posts. For design situations other than these, the reader can expand the principles outlined in this paper with the aid of the references. For instance, the effects of additional rows of posts can be seen if the charts given in reference 3 are replotted using the redefined parameters of references 1 and 2, as was done (for one row of posts) in illustrations in this paper.

Discussed first are the compressive buckling concepts involved in bending of the structure. Considerably more space is devoted to this case than is devoted to shear buckling due to torsion of the structure for two reasons: (1) The theory and quantitative criteria have been developed to a much higher degree for this case. (2) Most of the fundamental concepts involved in this case are also applicable to an understanding of torsional buckling.

The behavior of the posts in stabilizing compressive buckling can be demonstrated with a simple column laterally supported at its midpoint by a pin-ended translational spring, Fig. 3. If the spring is weak, Fig. 3(a), the column behaves in a manner similar to that of an unsupported column but buckles at a slightly higher load, depending on the strength of the spring. If the rigidity of the spring is progressively increased, the buckling load also increases up to the point where this buckling load is equal to that required for the column to buckle into two half-waves with a node at the spring, Fig. 3(b). From this point on, increasing the rigidity of the spring has no effect whatever upon the buckling load, because it can do no more than cause a fixed nodal point, and the spring is effectively infinitely rigid. At this point, also, the spring ceases to carry any load

* From preliminary design estimates.

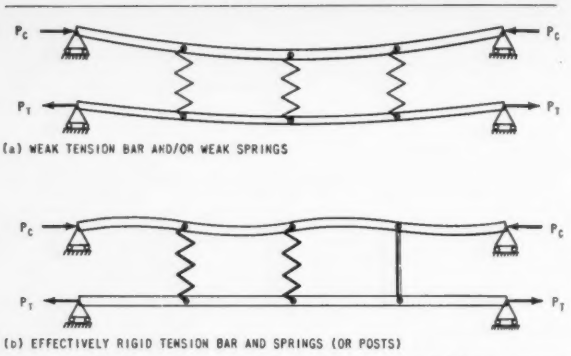


FIG. 4. Buckling modes for spring-stiffened parallel bars. From NACA data.[4]

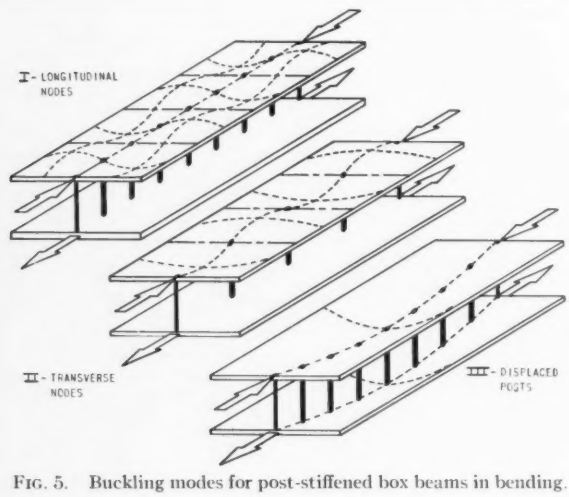


FIG. 5. Buckling modes for post-stiffened box beams in bending.

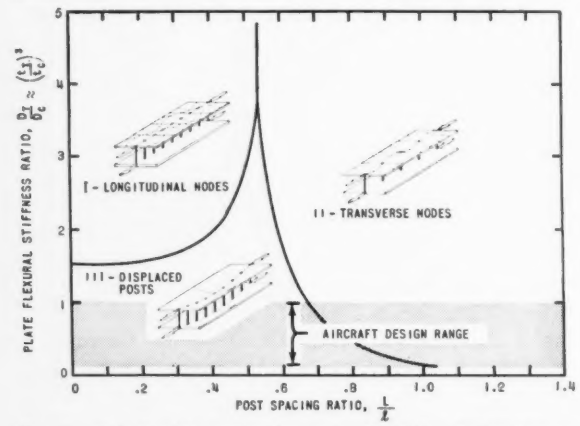


FIG. 6. Relationship controlling type of buckling for box beams in bending with rigid posts and no stringers. From NACA data.[3]

since its load is equal to its spring constant times its deflection, and its deflection is zero. Therefore, the spring can be replaced with a simple link, or post [Fig. 3(c)], which does not have to be strong but must only supply at least the critical value of spring constant.

If this link or spring rests upon an elastic foundation, then the same basic principles apply also to the foundation. Fig. 4 shows two parallel bars connected by a series of springs with one bar loaded in compression and the other in tension. The compression bar is stabilized by its own bending stiffness plus the support offered by, or transmitted through, the springs, and it is destabilized by the action of its own compression load. The tension bar is stabilized by its own bending stiffness and by its tensile load, but it is destabilized by the load transmitted through the springs and is therefore capable of "buckling."

If either the tension bar or the spring system is weak, the complete system will buckle out as shown in the top sketch [Fig. 4(a)]. The springs will be loaded and will cause deflections in the tension bar. If, however, the combination of springs and tension bar becomes sufficiently stiff, the compression bar will be forced to buckle into half-waves that are equal in length to the spring spacing and which have nodal points at each spring [Fig. 4(b)]. From this point on, the springs and the tension bar are effectively rigid and are not required to carry any load derived from their stabilizing function. No further increase in rigidity of the tension bar or the springs will change the critical buckling load of the compression bar. The springs can be replaced by small posts as indicated in Fig. 4(b).

The basic principles just discussed are fundamental in discussing the buckling behavior of the post-stiffened wing as can be seen throughout the following discussion.

A post-stiffened box beam is capable of three basic modes of buckling under the action of bending loads (Fig. 5):

(1) *Buckling with Longitudinal Nodes.*—In this case the posts and their supporting structure are effectively rigid, and their behavior is similar to a spar. The compression plate buckles in square waves on each side of the row of posts and has a straight node line along the posts. This is the highest energy type of buckling obtainable.

(2) *Buckling with Transverse Nodes.*—In this case, as in the first case, the posts and their supporting structure remain effectively rigid and do not displace vertically. However, the posts are far enough apart so that the compression cover and its stringer, if any, may buckle in between posts (similar to the rigid-spring action of the parallel bars in Fig. 4). Straight node lines are established transversely across the beam as though there were a rib at each post. These first two cases can be analyzed by standard methods.

(3) *Buckling with Displaced Posts.*—In this case the posts and/or their supporting structure are relatively weak, and the complete system buckles, including the tension cover and its stringer. This is considered the

least desirable type of buckling because it involves both covers; it represents the greatest amplitude; and it is, in general, the lowest energy state. It is also the most difficult to handle theoretically. Special criteria are required to avoid or to design for this type of buckling.

These three modes of buckling are possible regardless of whether stringers are present.

Consider first the case in which no stringers are present. In this case the conditions under which each type of buckling is possible can be defined with only two parameters. These two parameters are the ratio of flexural stiffnesses of the two cover plates, D_T/D_C, and the ratio of the post spacing to the distance between the line of posts and the adjacent spar, L/l. In Fig. 6, it can be seen that combinations of these two parameters fall into three separate zones, where each zone represents one of the three types of buckling. The most desirable type of buckling, with longitudinal nodes, is found in the upper left zone; the transverse node type of buckling is found in the upper right zone; and the least desirable type of buckling with displaced posts is found in the lower left zone. At the boundaries between these zones, two types of buckling are equally possible.

Also shown in Fig. 6 is a shaded area entitled "aircraft design range." This area is established on the basis that the compression cover is normally designed thicker than the tension cover, and the plate stiffness ratio will consequently be less than 1.0. It is immediately apparent that the aircraft design range encompasses the two least desirable buckling modes and excludes the most desirable type of buckling.

This situation can be improved markedly by the addition of stringers along the lines of posts. Fig. 7 shows the zone boundaries for two typical stringers, a moderately stiff stringer "A" and a somewhat stiffer stringer "B," and their relationships to the basic boundaries for the case of no stringers. The stringers have the effect of enlarging the most desirable zone and decreasing the size of the least desirable zone, and this effect is increased as the stiffness of the stringers increases. In fact, with stringer "B" the displaced post zone has been virtually eliminated from consideration. This illustrates the fact that stringers play an important part in the design of post-stiffened wings.

The action of the stringers in shifting the zonal boundaries can be seen by referring again to Fig. 5 in conjunction with Fig. 7. The addition of stringers along the post line adds rigidity to the line where longitudinal nodes are desired. This restrains the buckles against forming between posts, thus causing the transition between longitudinal node buckling and transverse node buckling to occur at larger post spacings and shifting the boundary to the right. Also, the additional rigidity supplied by the stringers replaces some of the "foundation" rigidity previously supplied by the tension plate, and the condition of effectively rigid posts-plus-foundation can be achieved with a thinner tension plate. Thus, the transition between displaced

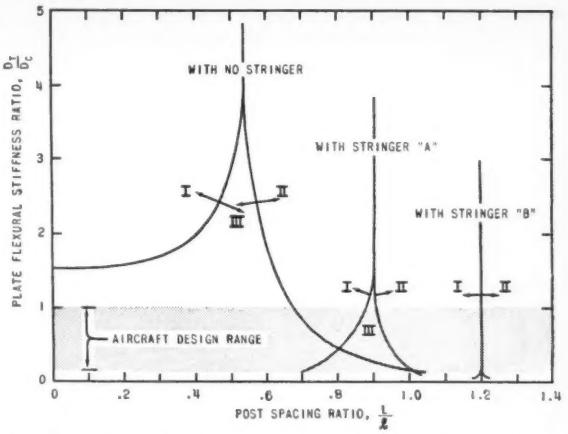


FIG. 7. Effects of stringers on relationship boundaries between types of buckling.

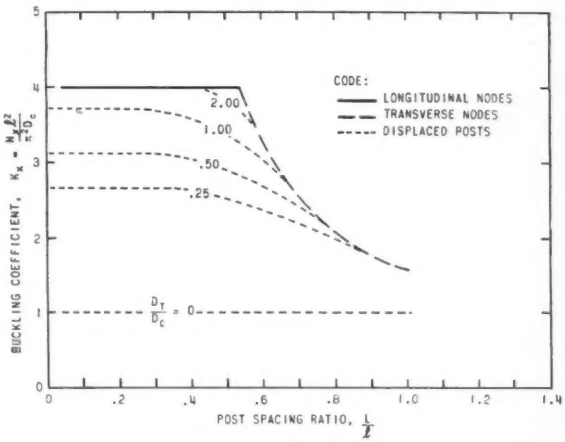


FIG. 8. Buckling coefficient for box beams in bending with rigid posts and no stringers. From NACA data.[3]

post buckling and longitudinal node buckling occurs at lower plate stiffness ratios, and the boundary is shifted downward.

A more quantitative evaluation of the three buckling modes is illustrated in Fig. 8, in which the stringers are again temporarily omitted. In this figure, the attainable buckling coefficients for all buckling modes are plotted against the post spacing ratio. The buckling coefficients are given in the general form in which a value of 4.0 represents buckling of the small compression panels between the line of posts and the spar, or longitudinal nodes. A value of 1.0 represents buckling of the compression plate alone from spar to spar.

Longitudinal node buckling is possible at post spacings below the critical value and is represented by the solid horizontal line. The buckling coefficient in this case is constant at $k = 4.0$, which is the highest value obtainable. Transverse node buckling is possible at post spacings beyond the critical value and is represented by the dashed curve. The buckling coefficient in this case decreases with increasing post spacing. In both of the above cases, it is required that the plate stiffness ratio criteria be satisfied. If the plate

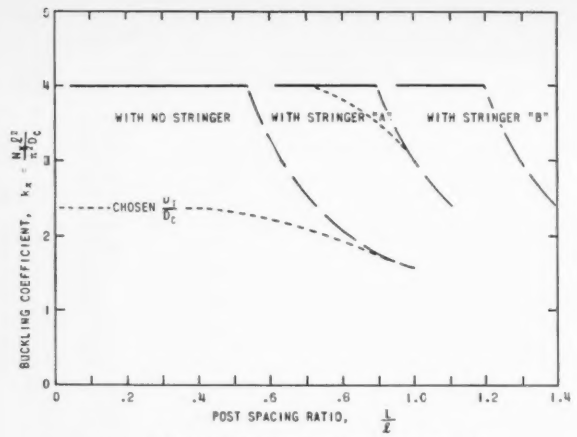


FIG. 9. Effects of stringers on buckling coefficient.

stiffness ratio falls below its critical value for a given post spacing, then displaced post buckling will occur, and the buckling coefficient drops to a value indicated by the appropriate dotted curve. (It might also be noted that the intersections of the various curves in this figure establish the boundaries shown in Fig. 6.)

The effects of adding stringers are shown in Fig. 9. In this figure, curves for each type of buckling are reproduced for the design without stringers, with only one typical D_T/D_C being chosen to represent displaced post buckling. Equivalent curves are also shown for design with stringer "A" and with a more rigid stringer "B." The addition of stringer "A" shifts the transverse node type of buckling (dashed curves) out to larger post spacings because of the ability of the stringer to resist buckling between posts. It also raises the energy state, and hence the buckling coefficient, of the displaced post buckling (dotted curves), so that the maximum buckling coefficient of 4.0 and the desirable longitudinal nodes can be achieved at both longer post spacings and lower cover stiffness ratios. The addition of the heavier stringer "B" extends these trends even farther and eliminates the displaced post type of buckling for the chosen value of cover stiffness ratio, D_T/D_C.

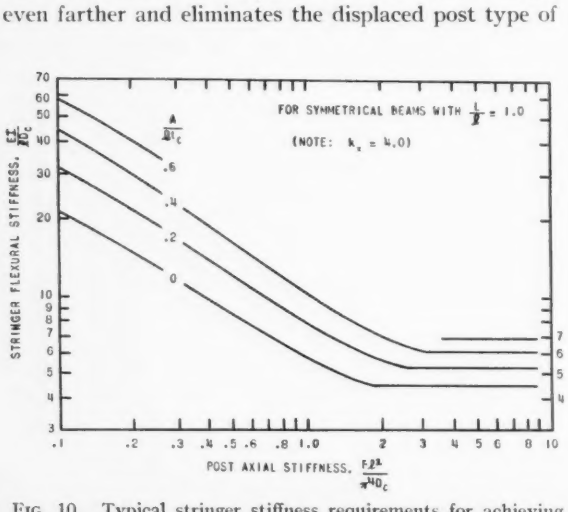


FIG. 10. Typical stringer stiffness requirements for achieving longitudinal nodes. From NACA data.[2]

This again illustrates the value and importance of stringers in the design of post-stiffened wings. Stringers are essential if longitudinal nodes are to be obtained with normal aircraft cover thicknesses.

The emphasis placed on longitudinal nodes may seem exaggerated, since experience with conventional stringer-stiffened wings has shown that the highest strength-to-weight ratios are not always achieved with the highest buckling coefficients. However, as will be shown later, the sizes of stringers required in the post-stiffened wing are extremely small by comparison with those required in the conventional stringer-stiffened wing. It is believed that, in the post-stiffened wing, the highest strength-to-weight ratios will be achieved with longitudinal nodes, although no studies along this line have been made for a very practical reason. Stringers are a practical means of attaching the posts to the skin, and it has been found that, if these stringers are large enough to provide adequate edge distance for the fasteners (post-to-stringer and stringer-to-skin) and are designed to prevent crippling, they are normally sufficient to obtain longitudinal nodes.

The theoretical criteria necessary to design structures stiffened by both posts and stringers have been derived by the NACA and published in an NACA Technical Note.[1] These criteria are inherently extremely complex and require extensive computing on high-speed automatic computing machinery to reduce them to useful design curves. The NACA is currently conducting a program to obtain these design curves and is planning to publish the results in 1953. Some of the preliminary results of this program have been published,[2] and a typical set of curves is reproduced in Fig. 10.

Fig. 10 represents the stringer stiffness required to produce the desired longitudinal node buckling ($k = 4.0$) for long symmetrical post-stiffened box beams with the post spacing equal to the half-width of the covers and with the plate edges assumed simply supported. The required stringer stiffness parameter is plotted against the post stiffness parameter for various values of the stringer area parameter. Any point on one of the curves represents the minimum combination of post stiffness and stringer stiffness which will assure effectively rigid (simple) support along the centerline of the compression cover for the given stringer area. Any higher value of either stringer stiffness or post stiffness will, of course, supply the required support but will produce no increase in the load-carrying capacity of the cover.

By considering these two parameters separately, two other interesting observations may be made from the curves in Fig. 10. First, the "points"* at which these curves become flat represent the maximum post stiffness required for the posts to be independently

* Not actually well-defined points in the criteria.

considered effectively rigid.* The stiffness values are so low that they are relatively easy to achieve with small posts, and they form handy reference points in initial design. (Caution: These points are markedly affected by post spacing.) Second, the required stringer stiffness decreases to a certain minimum value and then remains constant. This constant value, as shown by the flat portion of the given curve, represents the minimum stringer that can be used to produce the desired longitudinal node buckling. These minimum values of stringer stiffness are less than one-tenth of the values required of stringers acting alone to produce the same stiffening effect, as will be shown later.

Some useful quantitative relationships can be developed from the flat portions of Fig. 10 and similar curves now available.[2] These relationships will, of course, be strictly valid only for designs having effectively rigid posts, but they may be considered as guides even for designs falling on the sloping portions of the curves. The first of these relationships is shown in Fig. 11.

Fig. 11 shows that with effectively rigid posts the minimum stringer stiffness required to obtain longitudinal nodes is independent of the ratio of cover thicknesses within the following limits: post spacing ratios of 1.0 and above, plate stiffness ratios of 0.125 and above, and stringer area parameter values at least up to 0.2.† This is extremely useful information, since it eliminates the consideration of relative cover thicknesses for the case of design with rigid posts within the limits stated.

Using Fig. 11 as a basis, it is now possible to compare directly box beams with longitudinally stiffened covers with and without posts. Fig. 12 shows this comparison. The right-hand curves are replotted from criteria for stiffened compression panels[6] and therefore represent the case of no posts. The left-hand curves were replotted from the flat portions of curves similar to those in Fig. 10 and therefore represent the case of effectively rigid posts. It can be seen that, if posts are present, high buckling coefficients can be achieved with much smaller stringers than would be necessary to achieve the same buckling coefficients without posts.

This relationship is shown more graphically in Fig. 13, which shows how much smaller the stringers can be in a post-stiffened beam and still achieve longitudinal nodes. This figure is plotted from the values shown

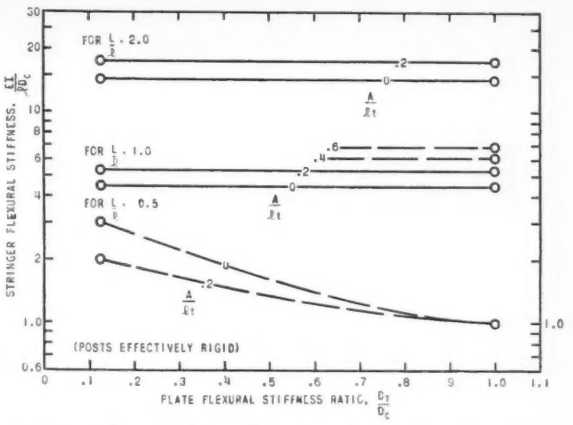

FOR L/l = 2.0
FOR L/l = 1.0
FOR L/l = 0.5
(POSTS EFFECTIVELY RIGID)
STRINGER FLEXURAL STIFFNESS, EI/lD_c
PLATE FLEXURAL STIFFNESS RATIO, D_T/D_c

FIG. 11. Effects of plate stiffness on stringer stiffness required to achieve longitudinal nodes.

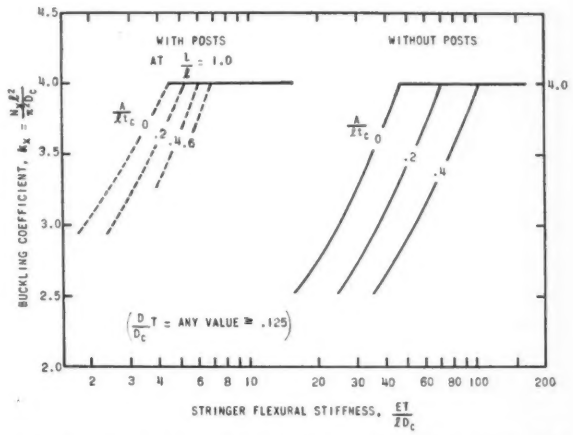

WITH POSTS AT L/l = 1.0
WITHOUT POSTS
(D/D_c T = ANY VALUE ≥ .125)
BUCKLING COEFFICIENT, k_x = N_x l²/π²D_c
STRINGER FLEXURAL STIFFNESS, EI/lD_c

FIG. 12. Comparison of longitudinally stiffened box beams in bending with and without posts. From NACA data.[2,6]

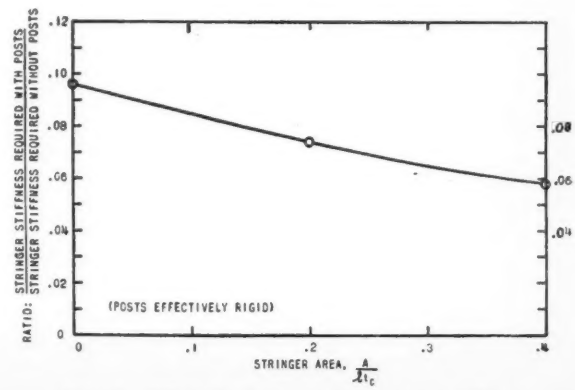

RATIO: STRINGER STIFFNESS REQUIRED WITH POSTS / STRINGER STIFFNESS REQUIRED WITHOUT POSTS
(POSTS EFFECTIVELY RIGID)
STRINGER AREA, A/lt_c

FIG. 13. Effect of posts on required stringer stiffness.

* With smaller values of post stiffness, the combinations of posts and stringers defined by the sloping portion of the curves will also be effectively rigid, but the posts will not be independently rigid. The terminology "rigid posts" is used in this paper to mean the range of post stiffness in which the required stringer stiffness is not affected by increases in post stiffness.

† Figure 11 contains all the information available at the time of this writing (shown by the circled points) and is expected to be applicable to even smaller post spacings and plate stiffness ratios and larger stringer areas when more data are available. However, even in its present state, this figure is extremely useful for design purposes, since the values stated above cover the usual design ranges for post-stiffened beams.

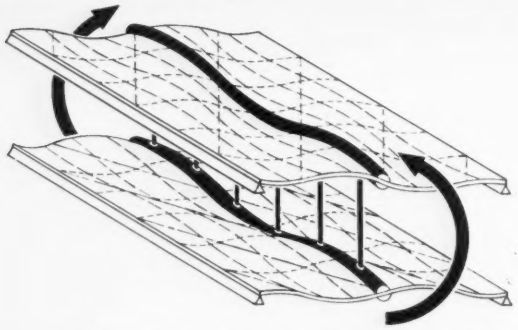


FIG. 14. Basic torsional buckling mode for box beams with posts and stringers.

in Fig. 12 for $k = 4.0$. It shows that with posts present the stringers can be less than one-tenth as stiff as stringers acting alone.

In the discussions above, no mention has been made of design criteria for the posts themselves. The reason for this is that the posts theoretically receive no load from their stabilizing action if they (independently or in combination with stringers) are effectively rigid and establish longitudinal or transverse nodes. They must, however, resist some crushing load because of the curvature of the covers, which tends to cause the covers to "pull in" toward each other. They must also resist any local air loads. It is wise to be conservative in establishing design loads for the posts for the reasons given in the discussion on test results [Section (V)] and because the weight of the posts required is small.

Because the posts are inherently small, another interesting point arises. If more than one fastener is used at each end of the posts, the post-stringer system becomes a kind of Vierendeel truss. The resulting end moments on the small posts may become a major design factor in the size and shape of the posts. In the Northrop Wing single fasteners were used to eliminate this effect (as well as to minimize the number of internal connections). Single fasteners, on the other hand, have the following disadvantages: (1) They are more subject to wear, brinelling, and fatigue in service. (2) More dependence is placed on good quality during fabrication.

(IV) Torsional Buckling Concepts

Torsional buckling of post-stiffened beams is much more difficult to treat theoretically than is compressive buckling, and quantitative design data have not yet been established. The reason for this lies in the basic limitations of the energy method used for deriving the stability criteria.

The Raleigh-Ritz energy method has been widely used in the solution of stability problems and is the tool used to derive most of the buckling criteria in existence today. It was the tool used to derive the criteria for the compressive buckling of post-stiffened beams. But when this method was applied to shear buckling problems, the lack of symmetry of the wave form prevented the elimination of the unknown Fourier coefficients from the stability criteria.

The solution in this case depends upon approximation by the use of the theory of infinite determinants. For simple problems, these determinants converge rapidly and can be chosen small enough to permit reasonable computations with satisfactory accuracy. However, inclusion of the five load-carrying elements (two plates, two stringers, and the posts) necessary to the solution of the post-stiffened beam makes the convergence slow and calls for large-order determinants for reasonable accuracy. The computing problem becomes enormous and taxes the capacity of even our most modern computing machines. Also, since the equilibrium equation is approximated rather than satisfied identically, the buckling load found by the iterative solution is inherently on the unconservative side, and rough approximations can be dangerous.

These factors are brought out not to make the task sound impossible but to point out the need for more powerful basic methods or extensions of present methods for treating stability problems, particularly for problems involving shear loads. Until such methods or extensions are developed, it will be necessary to undertake expensive and time-consuming computational programs to obtain design data for such problems as this one. Since sufficient need must be demonstrated before such a program can be undertaken, the required results will inherently lag behind the need. In this case, precise design data are not expected for many months.

Enough of the fundamental buckling concepts can be established at this time, however, to permit design on a practical, if somewhat conservative, basis. Fig. 14 illustrates the buckle pattern for a section of a long symmetrical post-stiffened box beam with equal and opposite shear loads (such as would be produced by pure torsion) on the two covers.

Buckle wave forms are created which run diagonally in one direction in the top cover and diagonally in the other direction in the bottom cover. These wave forms are oriented across each other, but they have exactly the same wave length because of the symmetry of the beam. If a vertical plane is established which contains the centerline of both plates, the wave-form traces of the two covers on this plane will be found to be identical in both wave lengths and amplitude and will have node points at the same spanwise positions along the beam. If there are no posts present, these wave-form traces will inherently rise and fall either in phase or 180° out of phase. The addition of posts merely ensures that they will occur in phase; it does not affect the buckling energy level.

Thus, the addition of posts to a perfectly symmetrical box beam does not raise the buckling load for pure torsional loads. The posts add no stability to the system, and they receive no load from the buckling of the covers. [They do receive load from other sources, however, see Section (V).]

In the case of unsymmetrical box beams, the addition of posts will affect the torsional buckling energy level under certain circumstances. That is, whenever the two covers, together with their respective stringers, tend to buckle with different wave lengths, the addition of posts will force them to buckle with a common wave length and wave form along their centerlines. This will, of course, increase the buckling load of the weaker of the two covers. It will also tend to increase the buckling load of the stronger cover, because it tends to force this cover to buckle in a pattern that is different from its natural (free) pattern. The net effect is that the complete system will buckle at a load that is somewhere between the critical loads of the two covers considered independently. The buckling load will be determined by the stability of the complete system and will probably be closer to the critical load of the stronger cover than would be predicted by simply taking an average value for the two covers.

However, even in the case of an unsymmetrical arrangement, it is conceivable that under certain circumstances the posts would provide no stability. The only requirements for this condition are that the covers, with their respective stringers, buckle in the same natural wave lengths and that the critical buckling loads of the two covers occur simultaneously. In this case, again, the covers buckle as though no posts were present.

Therefore, until accurate design data are available, the following procedure is recommended for computing critical torsional or shear loads. The buckling loads of the two covers should be computed separately as stiffened panels under shear loadings by methods that are already established.[7] The critical load of the weaker cover should be taken as the value calculated for that cover, and the critical load of the stronger cover should be taken as the average of the values for both covers unless sufficient bending is also present to cause the tension cover to remain unbuckled.

At first glance this may seem to limit severely the use of the post-stiffened beam. Actually, a symmetrical box beam with posts and stringers designed to buckle in bending at a certain magnitude of bending stress will resist at least 40 per cent of the same magnitude of shear stress (acting alone) before buckling. This is illustrated in Fig. 15.

Fig. 15 shows the compressive and shear buckling coefficients attainable for various values of the stringer stiffness parameter for three cases: (1) longitudinally stiffened box beams in bending with posts, (2) longitudinally stiffened box beams in bending without posts, and (3) longitudinally stiffened box beams in torsion with or without posts. The curves for the first two cases are repeated from Fig. 12 and are therefore valid for various cover thickness ratios. The curve for the third case is strictly valid only for symmetrical beams but can be used for unsymmetrical beams as explained above. The compressive and shear buckling coefficients have been reduced to the same terms so that they read on the same scale and so that the relative magnitudes of the shear and compressive stresses can be seen directly.

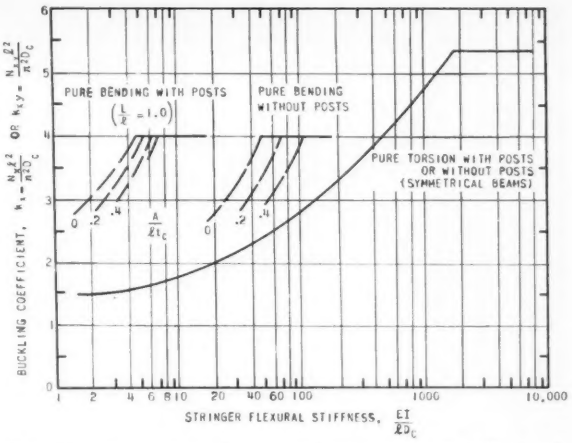


FIG. 15. Comparison of shear and compressive buckling coefficients with and without posts. From NACA data.[3, 6, 7]

The horizontal cutoff lines represent the highest obtainable buckling loads in each case and are achieved when the stringer and posts are sufficiently rigid to confine the buckles to the panels on each side of the stringer. The sloping curves represent buckling involving the stringer and are shown for several values of stringer area where this is a factor. The points where the curves meet the cutoffs establish the minimum stringer required to obtain longitudinal node buckling.

The relationship of critical shear stress to critical compressive stress can be obtained for any particular beam by reading the k_s from the shear curve at the pertinent value of EI/lD and comparing it to the k_c read from the pertinent compression curve directly above (at the same value of EI/lD). The lower limit of this relationship is 40 per cent and is found by dividing $k_s = 1.6$ by $k_c = 4.0$, as read for $EI/lD = 4.5$ (which is the lowest cutoff value for the post-stiffened beam in bending). At any other value of stringer stiffness, a higher ratio of critical shear stress to critical compressive stress is obtained. For most practical designs, it is safe to assume that a given post-stiffened beam will withstand 40 to 45 per cent as much shear stress as bending stress before buckling.

The critical value of shear stress is still, however, only about a third of the value obtainable with a full spar in place of the posts (shown by the cutoff on the shear panel curve). Therefore, the post-stiffened beam is recommended for applications wherein the shear stresses are not high compared to the bending stresses.

(V) TEST RESULTS

Experimental substantiation for some of the important theoretical concepts has been obtained by both NACA and Northrop Aircraft, Inc. To date, NACA has tested one beam in bending, and Northrop has tested three beams in bending and one in torsion and has begun another test to investigate combined load effects. The tests completed thus far have demon-

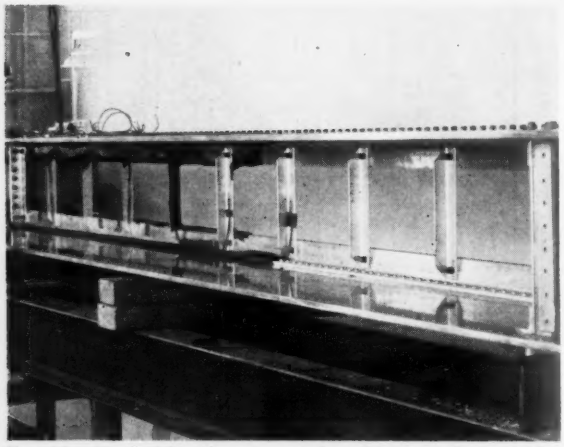


FIG. 16. Typical interior construction of test specimens (third bending specimen).

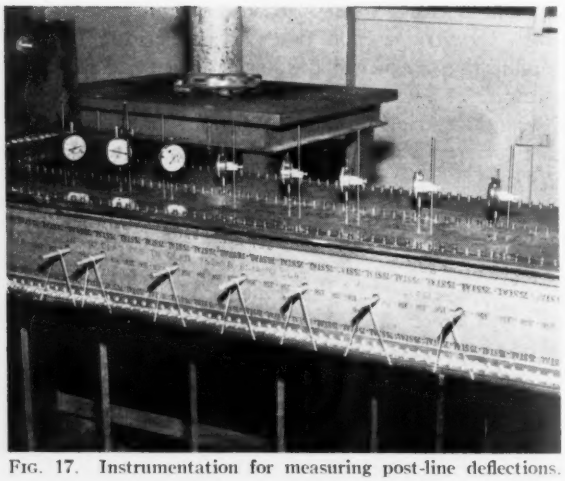


FIG. 17. Instrumentation for measuring post-line deflections.

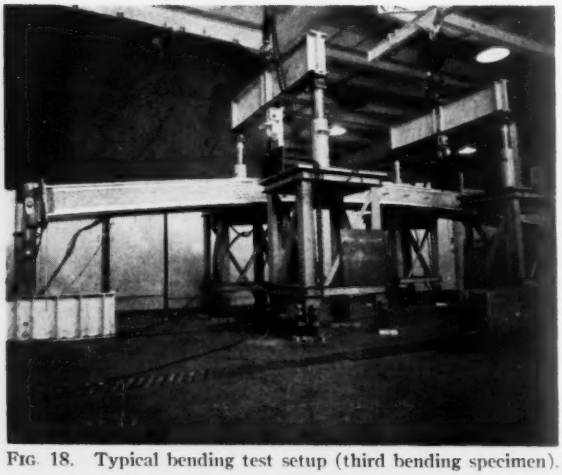


FIG. 18. Typical bending test setup (third bending specimen).

strated the validity of the theory (at least in the ranges tested) in an encouraging manner.

The results of the NACA test are reported in an NACA Technical Note,[12] and only the most pertinent general results are reiterated here. The specimen was a symmetrical box beam with three rows of posts and no stringers and was designed to buckle with transverse nodes. The test results show that it buckled in the predicted fashion and that it did so at the predicted load. A slight "dishing" of the cover plates was noticed during the test.

The Northrop tests[10] have all been on large-scale symmetrical box beams built (in full scale) to simulate closely portions of an actual wing design. As a result, the posts and stringers were somewhat stronger than the minimum required by theory because of attachment, crippling, and weight-efficiency problems which existed in the actual wing.

The test specimens had single rows of posts and were made of 75S-T6 aluminum alloy with basic test sections 105 in. long between ribs. The interior constructions were similar to that shown in Fig. 16. In all specimens, stringers were placed along the centerlines of the covers, and the posts were attached to the stringers with a single lockbolt at each end. The post spacings ranged from 8.00 to 10.50 in., giving post spacing ratios in excess of 1.0. The cover plate ranged from 0.188 to 0.375 in. in thickness and from 13.00 to 20.00 in. in width between spar cap attachments.

The specimens were carefully instrumented with strain gages to detect incipient buckling and to measure stresses. Buckling was detected by the use of pairs of strain gages placed "back to back" on the inner and outer faces of the compression cover. The load at which strain divergence* occurred in a pair of these gages was taken as the buckling load, and the buckling stress was taken as the average reading of the pair at this load.

Special means were provided to study the behavior of the post-stringer system, as shown in Fig. 17. Dial gages (sensitivity = 0.001 in.) were used to measure the deflections of one cover (the compression cover in the bending specimens) with respect to the spars. These dial gages were mounted on special inverted "T"-bar supports that extended, from inside the boxes, through holes in the centerline of the pertinent cover and which rested in holes at the centerlines of the two spar webs. This system provided reference points at the most stable points in the cross section, points that did not shift out of the reference plane under load. The dial gages made it possible to detect and measure extremely small movements of the post-stringer system.

The three bending specimens were all tested in the manner shown in Fig. 18. The beams were made somewhat longer than the basic test section to permit the development of pure bending moment by the application of two equal shear loads at the ends of the test

* Defined as the point at which the slope of the load-strain curve of one of the pair of gages became vertical.

section. The loads were applied smoothly by means of hydraulic jacks.

The first specimen was a box beam with covers 0.188 in. thick and 13.00 in. wide between spar attachment lines. This beam was designed to buckle with longitudinal nodes at a bending stress of 30,300 lbs. per sq. in. The measured stress at the point of strain divergence was 36,500 lbs. per sq. in., or approximately 20 per cent over that predicted for simply supported cover plate edges. Later studies of the effects of edge restraint by the methods given in references 8 and 9 (corrected for the presence of the stringer) indicated that the actual edge fixity in this beam could be expected to raise the buckling stress by approximately this same amount. Thus, the agreement between theory and test was considered good.

The buckles that developed in the cover were confined to the small panels between the stringer and the spars, exactly as predicted. As indicated in Fig. 19, these buckles had a half-wave length of 5.6 in. as compared to a panel width of 6.5 in.

The dial gages on the stringer showed a slight "dishing" of the compression cover which began at very low loads and progressively increased up to and beyond the buckling load. The maximum recorded deflection was 0.043 in. (after buckling). This "dishing" can be explained as follows: The greater curvature of the compression cover caused this cover to exert more inward crushing load than that exerted by the tension cover. This caused the post-stringer system to move to an equilibrium position slightly nearer the tension cover. The "dishing" did not seem to affect the buckling stress appreciably.

The second bending specimen was a box with covers 0.375 in. thick and 20.00 in. wide between spar rivet lines. This specimen had very light bent-up stringers (less than $^1/_4$ as thick as the covers) and light extruded spar caps. It was designed to buckle with longitudinal nodes.

Failure occurred at about 70 per cent of the predicted load and was attributed to the inability of the thin stringer and spar cap flanges to resist translational movements of the cover plate. Local flange deflections apparently permitted eccentricities in the cover plate which caused the buckles to progress across the full width of the box. There was no evidence to indicate that the post-stringer system assumed any general wave form other than a slight "dishing" similar to that found in the previous beam.

The third bending specimen was identical with the second except that it was designed with much heavier extruded stringers and spar caps which had flanges $^2/_3$ as thick as the cover plates. The revised stringer had approximately $2^1/_2$ times the minimum required moment of inertia but still only 20 per cent as much moment of inertia as that required of a stringer acting alone to produce the same stiffening effect.

In this test, failure occurred before any conclusive strain reversal was recorded, but the predicted stress level was reached before failure. The predicted buckling stress was 49,000 lbs. per sq.in. (corrected for plasticity), and failure occurred at a measured stress of 53,500 lbs. per sq.in. Later studies of the effect of edge restraint by the methods of references 8 and 9 indicated that the actual edge fixity would raise the predicted buckling stress by only a small amount, perhaps as much as 5 per cent.

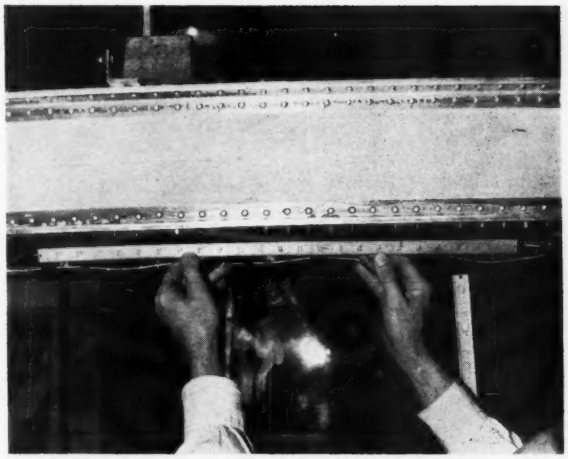


FIG. 19. Typical bending buckle pattern (first bending specimen).

Because of the close agreement between the theoretical buckling stress and the stress at failure, it is concluded that, with the heavy plate, buckling began and progressed explosively to failure. Attachment failures were noticed, and a large piece of cover plate (the size of a man's chest) separated completely from the cover and from the spar cap and stringer. The piece of cover was bent in a manner that indicated that the buckle had progressed across the stringer by failing the attachment to the stringer.

The torsion test specimen was a box with covers 0.250 in. thick and 17.00 in. wide (between the inside rows of double rows of lockbolts placed 0.80 in. apart through the spar caps). This specimen was tested in the manner shown in Fig. 20. The measured shear stress at the point of strain divergence was 31,000 lbs. per sq.in.

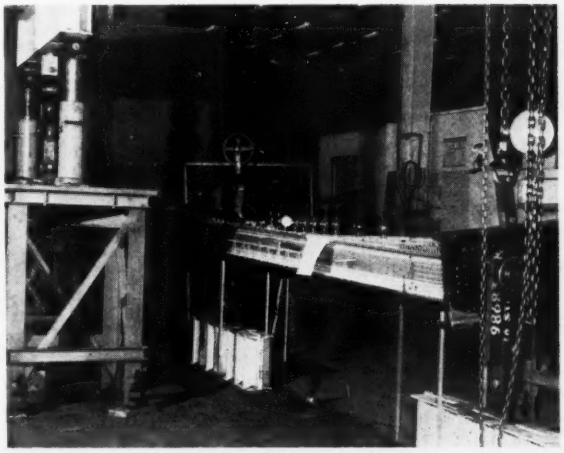


FIG. 20. Torsion test setup.

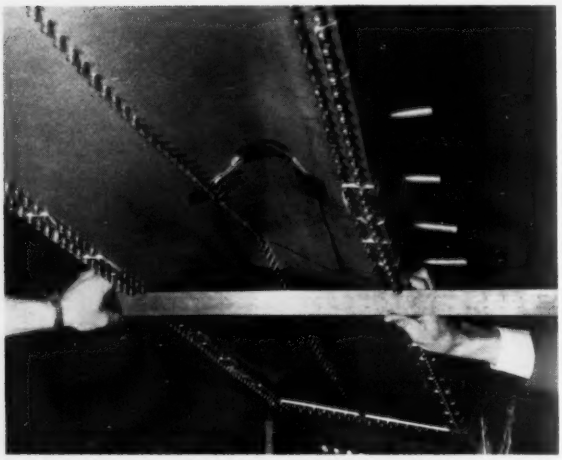


FIG. 21. Torsion test specimen after failure.

In this case, a large amount of edge restraint was obviously present because of the double row of fasteners and heavy spar caps, but no means were readily available for evaluating this restraint quantitatively. The theoretical shear buckling stress for simply supported edges is only 20,000 lbs. per sq.in. (from Fig. 15 with $EI/lD = 60$). However, by assuming the plate edges fully clamped at the inner row of spar fasteners, a theoretical shear buckling stress of 29,000 lbs. per sq.in. (corrected for plasticity) can be obtained.[7]

The buckle pattern developed was identical to that predicted by theory. Diagonal buckles ran clear across the box in opposite directions on the two covers. The stringers followed the wave patterns of their respective covers and these wave patterns were the same for both stringers. The dial gages showed an indication of a wave form in the stringers at very low loads, and the amplitude increased with load up to a maximum of 0.073 in. just prior to buckling. The same wave form continued after buckling but increased in amplitude. The orientation of the wave form in the covers is indicated in Fig. 21, which is a picture taken after failure of the beam.

The actual failure occurred in the stringer and posts at approximately 10 per cent above the buckling load. However, the theoretical collapsing stress of the cover, with the widely spaced ribs, is so close to the buckling stress (also true for multiweb beams) that this type of failure is not considered to be a weakness of long multi-post-stiffened beams.

The axial loads in the posts were measured in all tests, but only on an approximate basis because of the non-symmetry of the post cross sections and the limited number of strain gages available for this purpose. These loads were found to be somewhat higher than anticipated.

In the case of bending, the post loads were predicted on the basis of crushing loads alone, since the theory indicated no load in the posts because of their function of providing stability to the covers. However, the measured post loads were as much as 50 per cent above the calculated crushing loads (based on the average curvature of the beam).

In the case of torsion, no quantitative predictions were made of the post loads, although some load might be expected because of the diagonal tension and compression components of the shear loads acting on the warped (twisted) box. Again, no loads were expected which would be attributable to the stabilizing functions of the posts. The actual loads measured in the posts were similar in magnitude to those found in the bending tests.

A note of warning is in order here. In cases involving combined loads or unsymmetrical boxes under torsion, greater post loads can be expected, since the posts will theoretically receive some load from their stabilizing functions. No quantitative evaluations are possible at this time. At Northrop, a large margin of safety is maintained over calculated crushing and/or aerodynamic loads for the design of the posts and their attachments.

(VI) Concluding Remarks

Post-stiffened wings have been found to be practical in applications wherein the torsion loads are not high with respect to the bending loads. The theory for the case of bending loads is complete,[1–3] and the concepts are explained in some detail in this paper. The theory for the case of torsion loads is established only qualitatively, but enough is known to permit rational, if slightly conservative, design. The effects of the interaction of combined loads have not been established at this time and are not treated in this paper. These combined load effects are, however, currently under consideration in the form of theoretical studies being conducted at the NACA and further tests being conducted at Northrop Aircraft, Inc. As an interim measure, standard interaction equations[11] for flat plates are being used.

The theoretical predictions have been subjected to tests and have been substantiated in the ranges covered by the tests. The theory has been applied in the design of a wing for a modern high-speed airplane, and the post-stiffened wing construction has been found to be the most favorable type of structure for this particular wing. The theory has also been applied to designs of other structures, both with and without stringers.

From these studies, it has been concluded that there are design situations in which posts offer some decided advantages and that it is now possible to utilize posts with confidence on a rational engineering basis.

References

[1] Seide, Paul, *Derivation of Stability Criterions for Box Beams with Longitudinally Stiffened Covers Connected by Posts*, NACA TN No. 2760, 1952.

[2] Anderson, Roger A., Wilder, Thomas W., III, and Johnson, Aldie E., *Preliminary Results of Stability Calculations for the Bending of Box Beams with Longitudinally Stiffened Covers Connected by Posts*, NACA RM No. L52K10a, 1952.

[3] Seide, Paul, and Barrett, Paul F., *The Stability of the Compression Cover of Box Beams Stiffened by Posts*, NACA Report No. 1047, 1951. (Supersedes NACA TN No. 2153.)

[4] Seide, Paul, and Eppler, John F., *The Buckling of Parallel Simply Supported Tension and Compression Members Connected by Elastic Deflectional Springs*, NACA TN No. 1823, 1949.

[5] Budiansky, Bernard, Seide, Paul, and Weinberger, Robert A., *The Buckling of a Column on Equally Spaced Deflectional and Rotational Springs*, NACA TN No. 1519, 1948.

[6] Seide, Paul, and Stein, Manuel, *Compressive Buckling of Simply Supported Plates with Longitudinal Stiffeners*, NACA TN No. 1825, 1949.

[7] Crate, Harold, and Lo, Hsu, *Effect of Longitudinal Stiffeners on the Buckling Load of Long Flat Plates Under Shear*, NACA TN No. 1589, 1948.

[8] Anderson, Roger A., *Some Preliminary Information on Buckling and Ultimate Strength of Unstiffened Compression Skin Obtained Through Bending and Compression Tests on Rectangular Cross Section Aluminum Tubes*, Flygtekniska Försöksanstalten FFA, The Aeronautical Research Institute of Sweden, Report No. 27, 1949.

[9] Eggwertz, Sigge F., *Buckling Stresses of Box Beams Under Pure Bending*, Flygtekniska Försöksanstalten FFA, The Aeronautical Research Institute of Sweden, Report No. 33, 1950.

[10] Northrop Aircraft, Inc., *Test Results—Box Beams Stiffened by Posts and Stringers; Phase I*, Northrop Engineering Lab. Test Report No. ETR 6834-1. (Informal Report, not for general distribution.)

[11] Batdorf, S. B., and Stein, Manuel, *Critical Combinations of Shear and Direct Stress for Simply Supported Rectangular Flat Plates*, NACA TN No. 1223, 1947.

[12] Barrett, Paul F., and Seide, Paul, *An Experimental Determination of the Critical Bending Moment of a Box Beam Stiffened by Posts*, NACA TN No. 2414, 1951.

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Measurements of Turbulent Skin Friction on Cylinders in Axial Flow at Subsonic and Supersonic Velocities

By

Dean R. Chapman and Robert H. Kester

Ames Aeronautical Laboratory, NACA

The principal results of a study of various theories for calculating turbulent skin friction in compressible flow are briefly reviewed. These theories, 16 in number, predict widely different effects of Mach Number on skin friction and, hence, also on heat transfer. Such discrepancies emphasize the inadequacy of the present turbulent boundary-layer theory and the need for experimental measurements.

Systematic experiments have been conducted to determine the magnitude of turbulent skin friction along the cylindrical portion of insulated cone-cylinder bodies of revolution having overall fineness ratios of 10, 15, and 25. Data were obtained by directly measuring forces. Boundary-layer surveys were made to determine the correction necessary to apply to the force measurements in order to determine the effective starting position of the turbulent flow. Mach Numbers between 0.5 and 3.6 and Reynolds Numbers between 4 million and 32 million were investigated. At a Mach Number of 2.0, data were obtained for different pressure distributions (by distorting the flexible-plate walls of the wind tunnel), in order to evaluate the effect of a moderate pressure gradient on turbulent skin friction.

The results obtained with different pressure distributions showed no appreciable effect on average skin friction of moderate changes in pressure gradient. At both subsonic and supersonic velocities, the skin-friction coefficient was observed to depend only to a small extent on the body fineness ratio. For each fineness ratio, however, the effect of Mach Number was found to be large, amounting to approximately a 50 per cent reduction in skin-friction coefficient as the Mach Number is increased from 0 to 4. This effect of Mach Number did not depend on Reynolds Number or body fineness ratio and was found to be in good agreement with the experimental measurements made on flat plates by previous investigators. Several of the various published theories of turbulent skin friction agreed with each other and with the measurements to within about 5 per cent at all Mach Numbers investigated. At a Mach Number of 10, however, these same theories predict values of skin friction which differ greatly from each other, thereby indicating need for future experiments at hypersonic Mach Numbers.

Free-Flight Determinations of the Drag Coefficient of Spheres

By

Albert May and W. R. Witt, Jr.

U.S. Naval Ordnance Laboratory

Drag coefficients have been determined in the NOL Pressurized Ballistics Range for steel and aluminum spheres $^1/_4$ to $^3/_4$ in. in diameter. The Mach Number ranged from 0.8 to 4.7, and, by using air pressures from $^1/_{120}$ to 1 atmosphere, the Reynolds Number was varied separately over a range of 1.14×10^3 to 8.4×10^5. The drag-coefficient data obtained, together with the results of other investigators, permit a plotting of the variation of drag coefficient over a large region of Mach Numbers and Reynolds Numbers. The variation of C_D was found to be only about 10 per cent in the range $1.6 < M < 4.7$, and $4.0 \times 10^3 < Re < 1.0 \times 10^6$.

Supersonic Flow About Slender Bodies of Elliptic Cross Section

By

A. Kahane and A. Solarski

Republic Aviation Corporation and Cook Research Laboratories, Respectively

A theory for slender bodies of elliptic cross section in supersonic flow, based on the generalized cross-section slender-body theory of Ward, is presented. The theory is applied to the zero angle of attack pressure distribution on elliptic cones and parabolic arc bodies of elliptic cross section; results of several example computations are presented. Comparison is made with the nonlinear elliptic cone calculations and experimental results of Ferri; good agreement is obtained. The wave drag of bodies with elliptic bases is also treated. Application of the theory to bodies at angle of attack is indicated.

Preprint No. 397

Please do not order Preprints of these papers at this time.
See facing page for Preprints that are immediately available.

Supersonic Flow over Conical Bodies Without Axial Symmetry

By

Antonio Ferri, Nathan Ness, and Thaddeus T. Kaplita

Polytechnic Institute of Brooklyn

Conical flow around cones without axial symmetry is analyzed by the superposition of linear conical solutions to a nonlinear axially symmetric conical flow. The aerodynamic properties of cones with elliptical, drop-shape, and triangular cross sections are determined from these linearized solutions. It is shown that some gain on the shock drag can be obtained by using bodies having cross sections different from circular.

Bending Tests of Thin-Wall Sandwich Cylinders

By

George Gerard

New York University

A series of tests was conducted on thin-walled circular sandwich cylinders under bending loads using aluminum alloy faces and either cellular cellulose acetate or end grain balsa cores. It was found that for cylinders with cellular cellulose acetate cores, the buckling strength averaged 32 per cent higher than the theoretical value. From previous tests under compressive loads, excellent agreement was obtained between the corresponding theoretical value and tests. Thus, it was concluded

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that, under bending loads, the buckling stress depends on the average stress on the cross section rather than on the maximum stress. This behavior has been noted previously from tests on homogeneous cylinders.

A Constant-Area, Constant-Temperature Combustor

By

Philip Rosen and R. W. Hart

The Johns Hopkins University

The theoretical performance of a piloted constant-area, constant-temperature combustor with mass addition is studied. Perpendicular injection of mass at constant injection velocity and temperature is assumed. Mixing between the injected mass and the main stream is regarded as instantaneous. The flow is regarded as one dimensional. The effect of chemical kinetics is considered by the use of a simple rate equation. The exit velocity corresponding to maximum throughput is found to be $\sqrt{RT}$. The combustor length required to accelerate the gases to this velocity is found to depend on the reaction rate constants, flame temperature, input flow variables, and the temperature of combustion. It is found that there exists a lower limit on the temperature below which the combustor is unstable.

Studies of Some Effects of Airplane Configuration on the Response to Longitudinal Control in Landing Approaches

By

Ralph W. Stone, Jr., and William Bihrle, Jr.

Langley Aeronautical Laboratory, NACA

The investigation reported in this paper was undertaken to see if there are inherent differences in the response of the flight-path angle to control movements between swept-wing airplanes having no horizontal tail and using trailing-edge flaps for longitudinal control and conventional airplanes that are known to have satisfactory response characteristics. Particular emphasis is placed on the final few seconds of the landing approach.

This study shows that the only difference in the short-time response of the flight path between the two types of airplanes is in a time lag in the flight-path angle response of the swept-wing airplanes. This time lag was found to result from two factors: first, a relatively small value of the parameter

$$(VC_{L_\alpha}/2\mu\hat{c}) \quad (V^2C_{m_{\delta_e}}/2\mu K_Y{}^2)\Delta\delta_e$$

which is a measure of the effectiveness of the control in changing the flight-path angle and, second, a relatively large value of the parameter

Linear accelerometers are manufactured by Statham Laboratories for measurement in ranges from ±0.5g to ±1,000g. Unbonded strain gage accelerometers have higher natural frequency than is usually attainable with other types of pickoffs. For maximum possible output, the mechanical construction of these instruments is such that movement of the suspended mass produces a change of resistance of all four arms of the complete balanced bridge. The resistive nature of the bridge permits the use of these accelerometers in either A.C. or D.C. circuits.

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$(VC_{L_{\delta_e}}/2\mu\tilde{c})\Delta\delta_e$

which is a measure of the amount of undesirable change in lift accompanying the control deflection required to change the angle of attack. It had been suspected that the relatively large change in drag with angle of attack, of low aspect ratio swept-wing airplanes having no horizontal tails, would be an important factor in the flight-path angle response, but this was found not to be the case for the short time intervals under consideration.

The importance of the differences found in the response characteristics between the two types of airplanes studied can be evaluated only by flight experience. Other factors such as range of vision, control feel, the pilots' reaction to the relatively large nose-up attitudes of the low aspect ratio swept-wing airplanes, and psychological influences associated with new type airplanes may be of equal or greater importance.

Preprint No. 404

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

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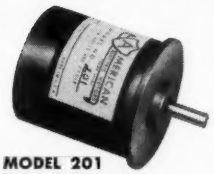

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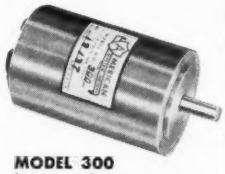

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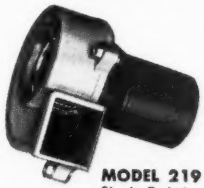
MODEL 182A
Axial Flow Fan



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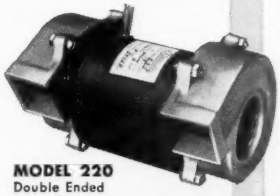

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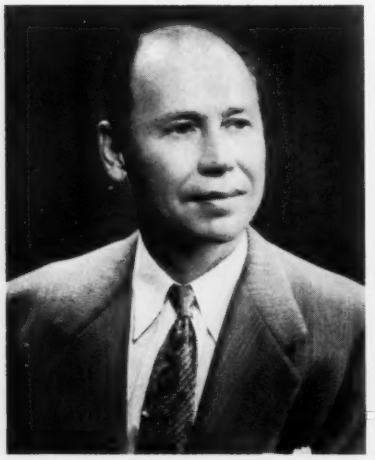
News of Members

(*Continued from page 21*)



Edward H. (Bob) Farmer, MIAS, was recently elected Vice-President—Manufacturing, Pacific Airmotive Corporation. Mr. Farmer who was formerly Works Manager at Lockheed Aircraft Corporation, had been with Lockheed since 1941. From 1929 to 1941, he was with the management group of E. W. Bliss Company. Mr. Farmer holds B.S. and M.E. degrees from Case Institute of Technology and has studied at Harvard Graduate School of Business.

L. Eugene Root (FIAS), has joined the staff of Lockheed Aircraft Corporation as Director of the Development Planning Department, recently created to work on long-range civil and military aircraft trends. As head of this group of selected scientists and technicians, Mr. Root advises Lockheed management on directions of airplane development; trends in power, speed, and aircraft capacity; utilization of scientific advances in various fields; and forecasts of new-type aircraft, missiles, and weapons systems. Mr. Root was formerly Chief of The RAND Corporation's Aircraft Division.

Donald W. Bedell, MIAS, has been appointed Special Representative to the Aviation Industry for Esso Standard Oil Company. As such, he is responsible for technical assistance and recommendations in aircraft lubricant and fuel problems. Prior to being appointed to this newly created position, Mr. Bedell was Head of the Aviation Group in Esso's Sales Engineering Division.

Emmet E. Baker (TM), Aviation Sales Engineer, Bendix Radio Communications Division, Bendix Aviation Corporation. Formerly, with Communication Division, Headquarters, Air Research and Development Command.

Dr. Chieh-Chien Chang (M), Research Professor, Institute for Fluid Dynamics and Applied Mathematics, University of Maryland. Formerly, Mathematics Department, The University, Manchester, England.

William H. Dammer (TM), Field Service Engineer, Boeing Airplane Company, Randolph AFB, Tex. Formerly, Boeing Field Service Engineer, Lowry AFB, Colo.

Dwain E. Fritz (M), Executive Vice-President, Royal Electric, Inc. Formerly, Director of Engineering and Assistant to the President, Jack & Heintz, Inc.

Jean L. Goulet (TM), Aerodynamicist "C," North American Aviation, Inc. Formerly, Private First Class, USA, Guided Missile Technician, 96th Ordnance Company, White Sands Proving Grounds, N.M.

Moshe Hadari (T), Senior Flight Engineer, Israel National Airlines, Israel. Formerly, Second Flight Engineer, Israel National Airlines.

Lester Lees (AF), Associate Professor of Aeronautical and Applied Mechanics, California Institute of Technology. Formerly, Associate Professor of Aeronautical Engineering, Princeton University.

Alexander J. Lilly (M), Executive Assistant to the Vice-President—Sales and Flight Test Advisor to the Vice-President—Engineering, Canadair Limited. Formerly Chief Test Pilot, Canadair.

William S. Longhurst (M), Chief, Flight Operations, Canadair Limited. Formerly, Pilot, Canadair.

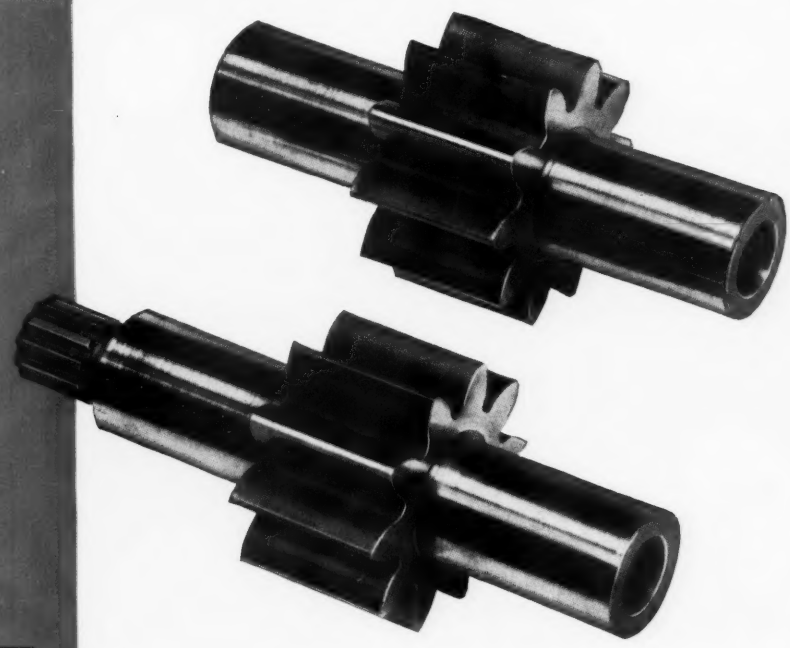
Robert M. Love (M), Chairman, Board of Directors, Allegheny Airlines, Inc. Formerly, President, Allegheny Airlines.

Peter P. Wegener (AF), Senior Research Engineer, Jet Propulsion Laboratory, California Institute of Technology. Formerly, Deputy Chief, Aerophysics Division, U.S. Naval Ordnance Laboratory, Silver Spring, Md.

Corporate Member News

• **Aeroquip Corporation...**Flex Joint, a new product designed to permit the flexing of rigid fuel lines in aircraft, has been introduced by Aeroquip. This new Flex Joint, basically synthetic rubber bellows bonded to aluminum inserts at both ends, functions to permit fluid-tight connections between two pieces of metal tubing under conditions such as wing deflections, vibration, thermoexpansion, and construction tolerances. Among the advantages claimed for this joint are: a compact fluid-tight seal under all conditions, the provision for angular movement of plus or minus 10°, the accommodation of axial misalignment of tube ends up to $^1/_{16}$ of an inch, the allowance for axial thermo-expansion of the tubing, and the dampening of high-frequency vibrations.

• **AiResearch Manufacturing Company...**A ram-air turbine that supplies emergency hydraulic power for jet aircraft in the event of engine failure at either high speed or landing speed has been announced by the Los Angeles company. The ram-air turbine can be extended into the air stream or installed in the main air duct. Its turbine wheel operates a pump that develops the necessary hydraulic pressure to operate the aircraft control system or other vital units whenever the main hydraulic power system fails. Its speed is automatically controlled. This new ram-air turbine weighs 15 lbs., is 12 in. in diameter, and occupies less than 0.75 cu.ft. of space. . . . A $4^3/_4$-lb. induction a.c. generator, half the size of an ordinary automobile generator, has been designed and is now being produced. This generator, which uses no brushes, is described as an 800-watt, 115/200-volt, 3-phase, 400-cycle unit. . . . A new 12-page



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bulletin, number *3-4-1*, covers the Williams grip electrical connectors completely, giving a full description of their operation, performance, applications, and dimensions. Photographs, schematics, exploded views, and graphs are also included in this two-color brochure, now available from this Los Angeles company.

• **Aluminum Company of America . . .** An Alcoa-owned stretcher with a 3,000,000-lb. pull is being installed at the company's Lafayette (Ind.) Works for the purpose of straightening and relieving strain on large aluminum extruded parts. These parts to be stretched will be made on either of two extrusion presses of 14,000- and 20,000-ton capacity at the Lafayette Works as part of the USAF Heavy Press Program. The complete stretcher is about 180 ft. long and about 5 ft. wide with a total weight of some 2,100,000 lbs. It is capable of handling pieces of metal up to 110 ft. in length and of straightening shapes, after extruding, up to 60 sq.in. in cross-sectional area in aluminum-alloy 75S for aircraft. . . . A 14,000-ton extrusion press has been installed at the Lafayette, Ind., plant. This press, a product of Dusseldorf, Germany, is to be used immediately on production for the U.S. Government under a lease arrangement between Alcoa and the USAF. In peacetime economy, the press will produce, among other things, aluminum pipe for the petroleum industry. . . . M. M. Schratz, who has been associated with Alcoa for more than 43 years and has been Controller of the company since 1947, was recently elected to a newly created Vice-Presidency of Alcoa.

• **Bell Aircraft Corporation . . .** The one-thousandth Model-47 helicopter rolled off the production line at Bell's Helicopter Division at Fort Worth, Tex., on April 18. This production mark was accomplished by Bell in less than 7 years after receiving "the world's first commercial helicopter certificate."

• **Boeing Airplane Company . . .** A 1,000-hour accelerated service testing program, conducted under simulated combat conditions, was completed last April by a Boeing B-47 Stratojet. During this shakedown program, this 185,000-lb. medium bomber made 121 flights, each of which averaged 8½ hours in duration and more than 3,000 miles in distance covered. All but three of the landings and take-offs were made at Wichita. Routine fuel transfers from a Boeing KC-97 Stratofreighter Flying Boom tanker were made during both day and night operations.

• **Breeze Corporations, Inc. . . .** Colonel Michael J. McCormack has been elected a Vice-President of the corporation. Colonel McCormack was recalled to active duty in 1951 and served as Director of Production for the Eastern Air Procurement District, USAF. With Breeze, he will have charge of all sales of the entire Breeze line of specialized mechanical and electronic devices for the aviation and automotive industries.

• **The Bristol Aeroplane Company of Canada Ltd. . . .** According to a recent company announcement, the Bristol Olympus turbojet and the Proteus turbo-

prop engines have successfully completed rigorous test schedules under their superiority production program. The Olympus, which is specified for the Avro Vulcan delta-wing bomber, completed a run of 150 hours' scheduled duration to test-type conditions. The Proteus 705, which will power the Britannia air liner, completed 200 hours' scheduled running, 150 hours of which were under full type-test conditions. These tests were conducted at the Bristol plant in England. The completion of the 200-hour duration run brings the total development-testing hours accumulated by Proteus engines to more than 13,500. This total is exclusive of the thousands of hours of running amassed in component testing.

• **Canadair, Ltd. . . .** Frank Pace, Jr., formerly Secretary of the Army, has been elected Vice-Chairman of Canadair's Board of Directors.

• **Consolidated Vultee Aircraft Corporation . . .** Following the transfer in March of 400,000 shares of Convair common stock from Atlas Corporation to General Dynamics Corporation, a new Board of Directors was elected at a special meeting on May 15. The Board was formerly composed of 12 persons; however, by virtue of an amendment to the company's by-laws the number on the Board has been raised to 20. Eight members of the former Board of Directors were re-elected. These are: Gen. J. T. McNarney, USAF (Ret.), Convair President; La Motte T. Cohu, Vice-Chairman; W. C. Rockefeller, AFIAS, Executive Assistant to the Board Chairman; John D. Hertz; S. R. Inch; I. M. Laddon, FIAS, Chairman of the Executive Committee; Donald N. McDonnell; and R. C. Patterson, Jr. The other eleven Directors elected at the May 15 meeting are: John Jay Hopkins, a Director, Chairman of the Board, and President of General Dynamics and Chairman of the Board and Managing Director of Canadair, Ltd., who was made Chairman of Convair's Board of Directors; Ellsworth C. Alvord, Attorney; George W. Codrington, a Director of General Dynamics and Canadair; Lambert J. Gross, Vice-President and Controller of General Dynamics and Assistant to the Board Chairman of Canadair; Roger I. Harris, Vice-President and Counsel, General Dynamics, and Assistant to the Board Chairman, Canadair; Henry M. Marx, Attorney; Clifton M. Miller, Vice-Chairman of the Executive Committee and a Director of General Dynamics and a Director of Canadair; J. V. Naish, Convair Executive Vice-President; J. Geoffrey Notman, President and a Director of Canadair and a Senior Vice-President and a Director of General Dynamics; Rear Adm. Lawrence B. Richardson, USN (Ret.), FIAS, a Director and a Senior Vice-President of General Dynamics and a Director and Vice-Chairman of the Board, Canadair; O. P. Robinson, Jr., a Senior Vice-President and a Director of General Dynamics; and Frank Pace, Jr., Executive V.-P. and a Director of General Dynamics, and a Vice-Chairman of Canadair's Board of Directors. . . . The election of D. T. Fisher as Controller and G. T. Bovee as Treasurer of Convair was announced recently. L. W. Miller, Vice-President—

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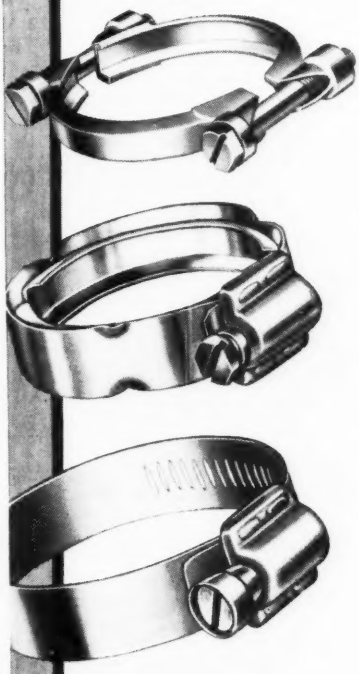

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Finance, who has also been Acting Treasurer since March of 1952, will continue as Vice-President—Finance.

• **Curtiss-Wright Corporation . . .** Marion E. Jordan, Jr., who has been with the firm for 13 years, has been elected Treasurer of Curtiss-Wright. He has been serving as Assistant Treasurer of C-W since 1949.

• **Douglas Aircraft Company, Inc. . . .** It was recently reported that Douglas has been given a contract to produce the XF5D-1, a lightened version of the F4D Skyray.

• **Fairchild Engine and Airplane Corporation, Stratos Division . . .** A brochure entitled "Stratos Constant Speed Air-Turbine Drives" has been published. It describes Stratos models TP15-2, TFP40-1 and TP3-1.

• **Fletcher Aviation Corporation . . .** Aircraft tip tanks, designed by Fletcher to fit Republic's F-84 Thunderjet and Lockheed's F-94 Starfire, are being manufactured under agreement by Norsk Flyindustri A/S, of Oslo, Norway. The first of these Norwegian-built American-designed tanks should be rolling off Flyindustri's production lines at Oslo's Fornebu Airport early this summer. This Norwegian company was previously building a British-designed tank for the de Havilland Vampire.

• **Flight Safety Foundation, Inc. . . .** Plans for a 3-day air-safety session have been announced. According to tentative plans, this session will be held in Europe, probably in Luxembourg, on September 1. This date will place the meeting immediately prior to the SBAC air show at Farnborough, England, and the Fourth International Aeronautical Conference in London, England. Among the topics under consideration for discussion are mid-air collision hazards and emergency survival equipment. . . . Flight Safety moved into larger quarters last May. The new address is 471 Park Avenue, New York 22.

• **G. M. Giannini & Company, Inc. . . .** A new linear-motion potentiometer, Model 8620 Rectipot, is now available. Standard models will operate in a temperature range of −55°C. to +71°C.; a new high-temperature model will operate between −55°C. and +149°C. These new Rectipot potentiometers can be had with either one or two electrically independent resistance units, both operated from the same shaft. Linear strokes of from 0.5 to 5.25 in. are available, and the shaft is free to rotate through 360°. . . . The formation of a European subsidiary, Giannini Italiana S.p.A., has been announced. The offices and laboratories are located at Via Alberto da Giussano 15, Milano, Italy. This Italian company provides sales and engineering headquarters for the distribution and servicing of the Giannini products; it maintains a research laboratory and experimental shop for developing new instruments of European origin.

• **Irving Air Chute Company, Inc. . . .** Roy R. Brockett, Secretary of Irving since 1937, died of a heart attack in Buffalo, N.Y., on April 13.

This series of photographs shows a take off of a Navy Grumman JFR Goose equipped with a pair of hydroskis with a configuration similar to those being tested on Convair's XF2Y-1 Sea-Dart. These hydroskis have been developed by Edo Corporation under U.S. Navy contract for the purpose of improving the take-off and landing characteristics of water-based high-performance aircraft. These Edo skis are mounted below the fuselage on shock-absorbing struts and are said to create "tremendous hydrodynamic lift while running under water."

• **Linde Air Products Company, Division of Union Carbide and Carbon Corporation . . .** A recently released catalog, *Heliarc Torches: Your Best Buy for Inert Gas Shielding Arc Welding* (Form 7979), is now available gratis.

• **Lockheed Aircraft Corporation . . .** It has been announced that the use of a deceleration parachute on the Lockheed F-94C Starfire on its landing roll has substantially lowered the wear on the fighter's brake installations, landing gear, and tires and has decreased by 40 per cent the landing distance. The parachute used on the F-94C production model measures 16 ft. in diameter, has a 24 per cent porosity, and has a drag coefficient of 0.49. In average packing practice, it is possible to arrange the chute in its deployment bag in 5 min. and stow the deployment bag in the aircraft ready for flight in 1.5 min. The deployment bag weighs 1.5 lbs. and is said to cause little increase in the weight of the entire system, which is about 65 lbs. Each chute is good for approximately 100 landings. This, compared with the expendable parachute expense of $250, means that it costs only $2.50 per landing to use the deceleration parachute. Extensive tests to develop this drag chute were conducted with the USAF Air Research and Development Command. The Starfire is said to be the first production fighter aircraft to have a drag-parachute installation. . . . The F-94C has been given a new nose. A pointed elliptically shaped plastic radome, developed after 18 months of company research and experimentation, has replaced the bulb-like nose formerly used on the F-94C. This change-over from the rounded to the pointed radome has increased the Starfire's speed by 5 m.p.h. . . . Lieutenant General Elwood R. Quesada, USAF (Ret.), was recently elected a member of Lockheed's Board of Directors. General Quesada commanded the Joint Task Forces conducting atomic energy experiments at Eniwetok.

• **North American Aviation, Inc. . . .** A booklet entitled *Box Kite to Sabre Jet* has been prepared by North American. It contains a listing of the official world speed records and the requirements for the official speed run.

• **Northrop Aircraft, Inc. . . .** An exclusive license to manufacture and market a Northrop-developed lifting tool has been given to R. H. Froom & Company, of Los Angeles, by Northrop. This tool was designed by the Development Section of Northrop's Standard Tooling Department to provide a safer and more economical method of handling forming dies during the melting process for re-use of the die metal. . . . Construction on new flight-testing facilities with an approximate area of 250,000 sq.ft. was begun last May on the 227-acre site assigned to Northrop at the USAF jet-aircraft center at Palmdale Airport, Calif. These facilities include a large flight service building, a utility building, and four smaller structures, all of which are expected to be completed by January 1, 1954. The total cost will be in excess of $2,500,000. Northrop is building and will operate the facilities with the approval and support of the Air Force.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation . . .** Three new test cells are now being constructed at the Andrew Willgoos Turbine Laboratory and, when completed, will bring to seven the number of cells available at the laboratory for gas-turbine and high-speed ramjet engine development. These three new cells of reinforced concrete will measure 90 by 25 by 44 ft. and will be housed in a new extension now being added to the north side of the laboratory building. Construction work on the test cells and the extension was begun last December 1 and is scheduled for completion sometime this coming September. Also under construction is a 26,364-sq.ft. service hangar designed to accommodate modern wide-winged and tall-tailed planes. This service hangar project, started last September, should be completed early next month.

• **Republic Aviation Corporation . . .** The northwest-southeast runway at Republic is scheduled to be extended by some 3,000 ft. to a total length of 7,500 ft. to accommodate the F-84F Thunderstreak. This runway extension project is under USAF jurisdiction with the USA Corps of Engineers handling all matters connected with the acquisition of land needed for the extension.

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This specialized EEMCO motor design employs an in line double spur gear reduction for heavier operating loads or applications where shock loads are experienced, such as air compressors. It is rated at 2½ h.p. for continuous duty, 27 volts D.C. Output speed is 3650 RPM. Unit includes radio noise filter and standard AND 20001 mounting pad and drive.

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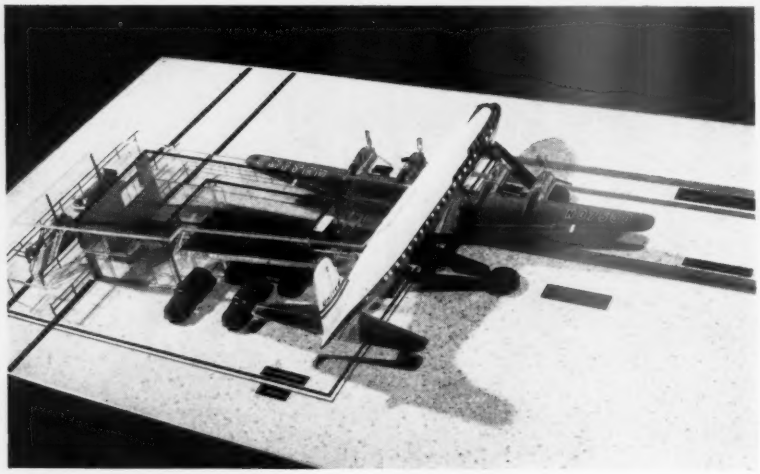


This picture shows a working model of an "airdock" designed by United Air Lines, Inc., to facilitate the loading and unloading of passengers, baggage, and cargo at air terminals. Further details of this proposed structure may be found in the U.A.L. item on this page.

• **Seaboard & Western Airlines, Inc. . . .** Six years of over-ocean operations were completed by this all-freight air carrier on May 9 when the company chalked up its 1,931 crossing of the Atlantic. The first flight was made by the company on May 10, 1947. Since that time, 22,100,000 revenue miles and 109,450,000 ton-miles have been logged in commercial and military operations across the Atlantic and Pacific oceans.

• **Shell Oil Company . . .** A gasoline additive, which has been used in Navy fighters and Air Force B-36 bombers for the past 2 years, is now being included in Shell's premium gasoline for motor cars. This additive, a cresyl compound known as TCP, is the result of research begun by Shell for the Air Force over 5 years ago. TCP causes the gasoline to be burned more efficiently, producing the full effects of increased power and mileage and ensuring reliability of spark-plug performance.

• **Solar Aircraft Company . . .** A small lightweight pneumatically operated jet-engine pressure control, known as the Solar Microjet, was recently announced by the company. This instrument, when in action on a jet engine, reportedly computes by itself under all flight conditions exactly what the pressure should be and, at the same time, notes any error between the actual engine pressure and what it should be. If there is an error, the instrument automatically sends out electrical signals to other engine controls that correct the pressure conditions. This Microjet control, which simulates a miniature jet engine, is said to require a minimum of maintenance, to be highly accurate, and to be so fast that pressure variations are recognized within 0.01 sec. . . . A $2,000,000 expansion of Solar's Wakonda plant in Des Moines, Iowa, is now under way. A 156,000-sq.ft. manufacturing addition is scheduled for completion late this year. The 60,000-sq.ft. office and engineering building is planned for occupancy next spring. The new construction on this 2-year-old plant is being undertaken to provide additional space for the manufacture of jet-engine parts.

• **Tinnerman Products, Inc. . . .** The election of two Tinnerman executives to important new positions was announced recently. These are Robert C. Overstreet, Vice-President and Secretary of Tinnerman, who was elected Executive Vice-President and re-elected Secretary, and John E. Potter, Controller, who was elected Treasurer.

• **Union Carbide and Carbon Corporation . . .** Thomas D. Cartledge was recently elected a Vice-President of Union Carbide and Carbon. Mr. Cartledge has been President of Linde Air Products Company, a Division of Union Carbide and Carbon, since May of 1952. He is also a Director and President of Dominion Oxygen Company, Limited (Canada).

• **United Air Lines, Inc. . . .** An "airdock," a two-level structure designed by U.A.L. to facilitate the loading and unloading at the ramp of passengers, baggage, and cargo, is being studied by company officials for initial installation. The proposed structure would be equipped with Whiting Loadair tracks, conveyor belts, and other devices for mechanized loading and unloading. The Loadair tracks would be built out to the taxi runway and would have a single track for the main landing wheels and separate nose-wheel tracks to fit all types of United's Mainliners. The upper floor of this airdock is designed to accommodate the movements of incoming and outgoing passengers and would be on a level with the Mainliner's cabin. The lower floor would be fitted to handle baggage and cargo. According to the company, this airdock would (1) protect passengers from inclement weather; (2) sharply reduce time required to deliver baggage to deplaning passengers; (3) provide greater safety and comfort for ramp employees; (4) eliminate most of the vehicles now cluttering the ramps; (5) substantially reduce airplane ground time at stations; and (6) greatly add to manpower efficiency in servicing aircraft. A picture of a working model of this airdock is shown to the left.

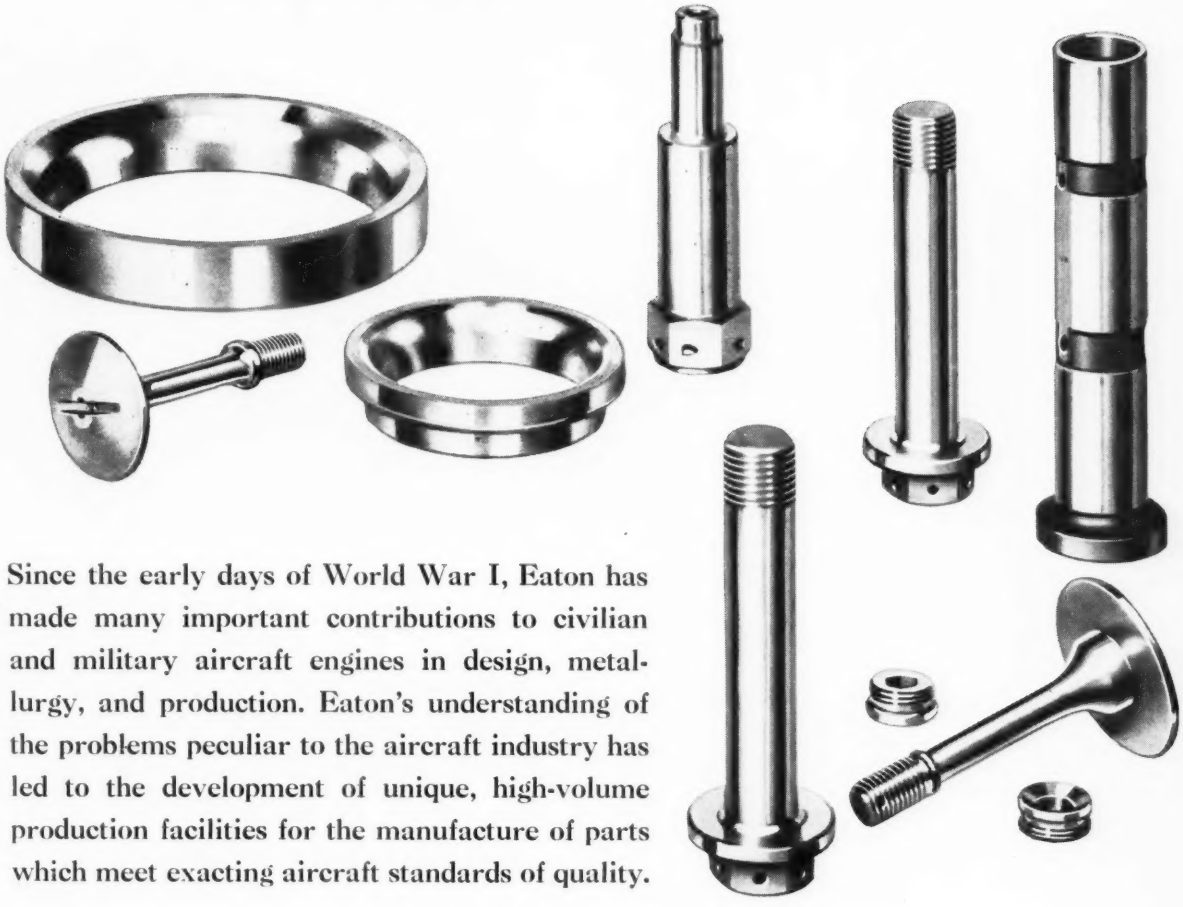
• **Vard, Inc. . . .** A new brick-and-steel Engineering Building, into which the entire Engineering Department has been moved, was constructed to facilitate Vard's newly instituted plan of market-product development. The new building adjoins other Vard properties on Foothill Boulevard in Pasadena, Calif.

• **Vickers, Inc. . . .** A universal turbojet-engine simulator for developing, testing, and calibrating fuel-control components for gas-turbine engines has been developed by Vickers in cooperation with the Navy's BuAer after 2 years of research and development work. Preliminary results indicate that the cost of final calibrations of fuel controls on an engine can be reduced to about 2 per cent of their present cost through the use of this device. It is said that with this simulator it will be possible for engine manufacturers to have a newly designed fuel system thoroughly tested and developed before it is installed on a prototype engine. According to company claims, a single-engined simulator is readily adaptable to testing fuel systems for all current gas-turbine engines, including (1) turboprop engines, (2) turbojet engines with fixed-area tail, (3) turbojet engines with afterburner, (4) turbojet engines with variable-area tail, and (5) turbojet engines with variable-area tail and afterburner. . . . *Bulletin A-5204*, which describes Vickers' complete line of relief valves in detail, is now available by writing to the Detroit office. Included in this descriptive brochure are the AA-31300 Series Valves, which have passed the AN Qualification Tests.

• **Westinghouse Electric Corporation . . .** In a recent action of the Board of Directors, five Vice-Presidents were elected. These are: Bruce D. Henderson, General Manager, Purchases and Traffic, who was elected Vice-President in charge of Purchases and Traffic; William C. Rowland, Manager of the Manufacturing and Repair Division, who became Vice-President in charge of that division; Franklin L. Snyder, Manager of the Aviation Gas Turbine Division, who was assigned to the staff of L. E. Osborne, Executive Vice-President, Defense Products Divisions; C. Swan Weber, Manager, Eastern District, who became Vice-President in charge of the Washington office; Robin S. Kersh, Executive Vice-President of Westinghouse Electric International Company, who became Vice-President of the parent company in charge of the Eastern District with headquarters in New York; and Leslie E. Lynde, Vice-President, Washington office, who became Manager of the Aviation Gas Turbine Division, succeeding Mr. Snyder. At the same time that the above changes were released, the retirement of Andrew H. Phelps as Vice-President in charge of Purchases and Traffic was announced. . . . John J. McCloy has been elected to the Westinghouse Board of Directors. Mr. McCloy was at one time U.S. High Commissioner for Germany and is now Chairman of the Board of The Chase National Bank of the City of New York.

Aircraft Parts by Eaton

combine outstanding developments in design, metallurgy, and production engineering



Since the early days of World War I, Eaton has made many important contributions to civilian and military aircraft engines in design, metallurgy, and production. Eaton's understanding of the problems peculiar to the aircraft industry has led to the development of unique, high-volume production facilities for the manufacture of parts which meet exacting aircraft standards of quality.

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IAS Sections

Baltimore Section

J. Francis Maloney, *Secretary*

The forty-second meeting of the Baltimore Section of the Institute of the Aeronautical Sciences was held in Remsen Hall of The Johns Hopkins University at 8:30 p.m. on April 21. The speaker was Donald J. Povejsil, of Westinghouse Electric Corporation's Air Arm Division. His subject was "Autopilot Systems—Basic Objectives and Types."

Mr. Povejsil's exposition of the basic objectives of autopilot systems, as well as their advantages and limitations, was well illustrated with slides.

Autopilots are necessary because they provide power boost, stability, and control which overcome the increased forces on the modern airplane and free the pilot for other duties.

More complicated versions could include directional, navigation, landing, tracking, and firing equipment. Complete flight programing, though possible, is probably not desirable when all factors are considered.

The latest autopilot is a rate gyro type of minimum weight (100 lbs.) and increased reliability.

Buffalo Section

George B. Melrose, Jr., *Secretary*

The March 11 meeting was held at the Touraine Hotel and featured a paper, "Design Features of the X-5 Airplane," by James A. O'Malley, Jr., Project Aerodynamicist, and Robert J. Woods, Airplane Design Consultant, both of Bell Aircraft Corporation. Mr. O'Malley presented the paper and some colored movies and slides of the airplane. The Program Chairman was Frank C. Kunze who also handled the security measures for the closed meeting. Approximately 70 members were in attendance.

Mr. O'Malley began his talk with a brief discussion of the history of the conception of the X-5 airplane. The distinguishing feature of the X-5 is the fact that it can vary the sweep of its wings in flight through a range of 20° to 60°. Its prime purpose is to investigate the problems of drag divergence, stability, and control over this sweepback range at high flight speeds. Preliminary design of the aircraft was initiated by Bell Aircraft in 1948. It is interesting to note that the airplane was designed to full tactical-fighter requirements and represents a prototype day fighter.

The speaker went on to describe the general physical characteristics of the airplane: pod-shaped fuselage, 9,900-lb. take-off weight, J35A17 turbojet engine (with provision for the XJ46-WE-2), manually operated control surfaces, and all-metal mid-wing monoplane. He discussed at length the feature of prime interest in the design—the wing-sweeping mechanism. In order to minimize trim changes during change of sweepback, the wing is designed to translate forward as it rotates to the higher sweepback angles. Selection of the aerodynamic location required consideration of each sweepback position from low to transonic speeds and over the entire angle-of-attack range. Low-speed wind-tunnel tests by NACA assisted considerably. The wing panels are mounted to the floating center section by a pin joint and by circular track-riding segments. The center section contains the wing-sweep actuating mechanism and the wing translational trolleys.

Mr. O'Malley went on to describe the structural design and actuating mechanism details with the aid of several slides. The design of an efficient wing-root section proved to be one of the more difficult structural problems, particularly for a full fighter load factor condition.

Mr. O'Malley also discussed the fuselage design problems, the unique features of the wing-fuselage movable fillets and details of the control system and its design problems. The Bell flight-test program, which began with the first flight on June 30, 1951, has indicated satisfactory characteristics at all sweep positions.

Two airplanes were delivered to NACA and the USAF in October, 1951. No aerodynamic or structural changes have been required during the extensive flight-test program of the airplane. The X-5 design has proved a successful addition to the line of USAF research airplanes.

Chicago Section

Charles L. Bonnette, *Secretary*

On November 25, the Chicago Section was honored by being the first professional engineering society group to be given the privilege of seeing the nuclear reactors at Argonne National Laboratory, 25 miles southwest of Chicago. After an informal dinner in the laboratory cafeteria, the members went in groups to the reactor area where senior members of the laboratory staff outlined the historical background of nuclear-reactor development, explained how reactors work, and then took the group on a tour of the facilities.

First to be shown was the experimental setup similar to that used by Dr. Enrico Fermi in 1942 to determine the feasibility of building a nuclear reactor. This was a half-room-size "pile" of graphite blocks surrounded by cadmium sheet, at the center of which was placed a "source" of neutrons. Nuclear information so obtained helped to form the basis for

The principals at the joint dinner meeting of the Chicago sections of the ASME and IAS on April 21 are shown. *From left to right,* they are: John W. Pocock, Coordinator of the program; William P. Lear, speaker and Chairman of Lear, Inc.; Dr. Harvard L. Hull, Chairman of the IAS Chicago Section; and Rodney Schaid, Aviation Division Chairman of the ASME Chicago Section.

Flight Tested!

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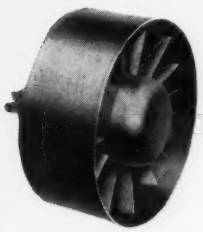
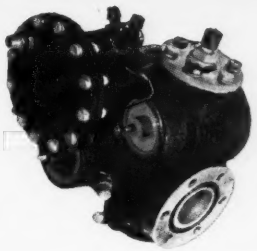
marquardt air turbine accessory drives and thrust controls for missile and aircraft power plants are the outgrowth of more than 8 years of research and development.

marquardt has created a new "Accessories Division" to facilitate mass production of these units for missile application.

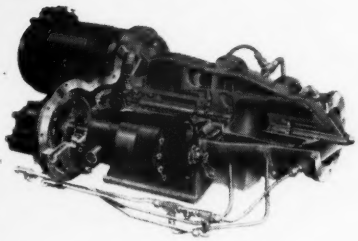
marquardt, pioneer in ramjet and afterburner research and manufacture, has new engineering manuals concerning these illustrated accessories. We'll be glad to send you a copy.



Ram air turbine driven unit for emergency aircraft power.

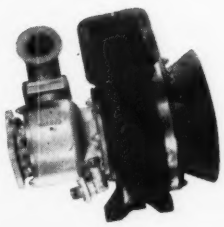


Supersonic ramjet engine power control.

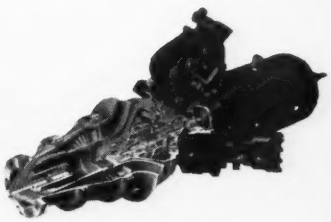


40 HP turbine driven unit, supplying electricity and hydraulic power.

Advanced design fuel nozzle for ramjets and afterburners.



Air turbine driven fuel pump.



50 HP turbine driven unit, supplying electricity and hydraulic power.

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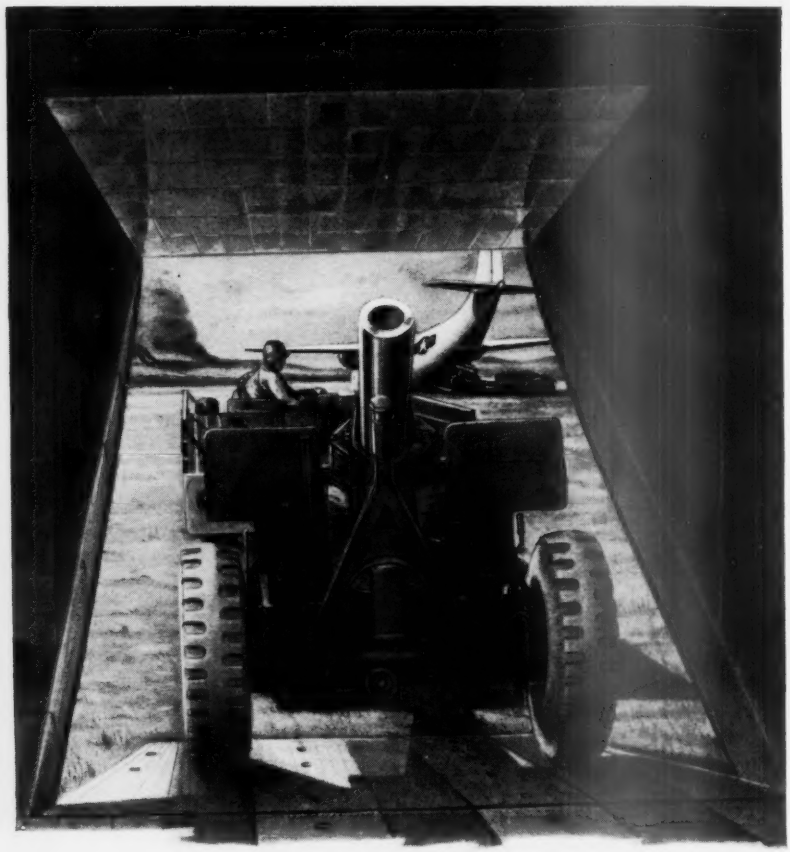
the design of the world's first self-sustaining nuclear reactor, which was visited next.

Because of delays in the construction of the reactor site, this reactor was first assembled, with no shielding, under the concrete football field stands at the University of Chicago. After the pile went "critical" on December 2, 1942, certain physical experiments were conducted, and the "pile" was disassembled and rebuilt at the isolated reactor site, outside the city limits of Chicago.

Inside the 5-ft. concrete shielding walls are tons of graphite blocks and chunks of natural uranium metal and uranium oxide. To the casual visitor, however, the reactor appears as a 30-ft. cube of concrete inside a large building with several scaffolds overhead supporting the control rods and experimental equipment. Since the "birthday" of this reactor 10 years ago, it has served as a testing ground for the design of the large research reactor at Oak Ridge, the tremendous production facilities at Hanford, and other installations.

The groups of IAS Chicago Section members then moved to the enriched-uranium and heavy-water reactor in an adjacent building and saw what a more modern, busy research reactor looked like. This reactor, in itself an experiment as the world's first reactor of this type, was first put into operation on May 15, 1944. First, the IAS visitors were shown the control room, the walls of which were lined with racks of instruments needed to operate the reactor properly. Here, the power was run down to 30 kw. and back up to 300 kw. to demonstrate the operation of the recently installed automatic controls. Next, the IAS members were taken into the reactor room and to the top of the reactor where they could look down upon the array of experimental equipment radiating from five sides of the octagon-shaped structure. This reactor consists of a 6-ft. tank of heavy water into which are suspended 120 enriched uranium rods. Around the tank is a 2-ft. layer of graphite blocks, a 4-in. shield of lead-cadmium alloy, and an 8-ft. concrete shield making a structure 13 ft. high and 27 ft. across. Numerous experimental openings penetrate the reactor to allow "beams" of neutrons to pass out for experimental purposes. Much of the world's basic nuclear information has been obtained through research conducted with this reactor. Booklets describing to the layman the construction, operation, and uses of these reactors were issued to all visitors.

▶ The Chicago sections of the Institute of the Aeronautical Sciences and the American Society of Mechanical



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Small unprepared fields – even in combat zones, present few difficulties to Chase Assault Transports. Heavy duty howitzers, with crews and prime movers are delivered to front line areas ***by landing*** ready for immediate employment – no time lost due to unpacking or reassembly.

The Chase Assault Aircraft is the only plane designed for this specific function and has more than fulfilled the exacting requirements of military necessity.

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AUTOMATIC
Aircraft Controls

. . . reliable actuators control hose and reel of probe and drogue system during inflight refueling!

Mid-air refueling . . . with probe and drogue . . . marks another key step in the progress of aviation. Thirsty jet planes aloft are fed hundreds of gallons of fuel per minute with this system developed and manufactured by Flight Refueling, Inc.

This means greatly extended range . . . permits take-offs with light fuel loads . . . makes possible many other new flight developments.

It's a *precision* operation throughout. And in the tanker's drogue unit, five Barber-Colman Actuators are used to *accurately control* the extension and return of the drogue hose.

Here is just another example of how Barber-Colman engineers team up with others in the aviation industry to help bring about important new developments for our military and civilian aircraft.

Three Barber-Colman JYLC Travel Limit Linear Actuators, and one JYLC Load Limit Linear Actuator as shown at right in inset, are utilized in the drogue unit produced by Flight Refueling, Inc.

Drogue unit also uses the Barber-Colman EYLC Rotary Actuator illustrated.

JYLC LOAD LIMIT LINEAR ACTUATOR

EYLC ROTARY ACTUATOR

Write for Bulletin F-4381-1 . . .
Gives facts and specifications on Barber-Colman Linear Actuators. Mail request to Dept. G, 1424 Rock Street, Rockford, Illinois.

The Barber-Colman line of aircraft controls includes: Actuators; Valves; Positioning Controls; Temperature Controls; Small Motors; Ultra-Sensitive Relays; Thermo-Sensitive Elements. Engineering sales offices in Los Angeles, Seattle, Chicago, Baltimore, New York, Montreal.

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Engineers held their annual joint aviation meeting on April 21 in the quarters of the Western Society of Engineers. Cocktails were served through the courtesy of Lear, Incorporated, followed by a fine dinner in a jam-packed main dining room, which attested to the interest in the meeting and the drawing power of the main speaker, Bill Lear.

During the after-dinner program, Dr. Harvard Hull, Chairman of the IAS Chicago Section, introduced the guests and officers of both societies, who were seated at the head table. Guests gathered to get Bill Lear's slants on automatic navigation included Ray W. Ireland, Vice-President of Traffic Administration, United Air Lines, Inc.; Clarence N. Sayen, President, Air Line Pilots Association, International; Dr. D. P. Barnard, Coordinator of Research, Standard Oil Company of Indiana; G. J. Scranton, Manager, Quality Control Office, Aircraft Engine Division, Ford Motor Company; and Col. R. L. Finkenstaedt, Commanding Officer, Mid-Central Air Procurement District. Moya Lear was present with her husband and proved a charming addition to the feminine contingent.

J. W. Pocock introduced the main speaker with a brief recountal of his career and contributions to date and his ambitions for the future. Mr. Lear, as Chairman of the Board of Lear, Incorporated, and the driving force behind that company's major contributions to automatic control in navigation, gave an extremely interesting informal talk in which he traced some of the highlights of his own career and discussed certain fundamental problems now facing us in the automatic control of high-speed aircraft. In his closing remarks, Mr. Lear underscored his belief that, if we are to provide the engineers required to service and maintain our increasingly complex military and industrial machine, we must go further than seeking to expand our university training programs and reach back into the pattern-forming years of the growing boy. The entire content of his talk provided a stimulating background for the Junior Prize Paper contest, sponsored by the Junior Papers Committee of ASME, which followed immediately afterward.

Before and after the meeting, those attending had an excellent opportunity to examine a wide variety of control devices placed on display by Lear, Incorporated. Two Lear representatives were present to aid Bill Lear in answering the many questions put to him by an interested group.

Cleveland-Akron Section

R. E. Bolz, *Secretary-Treasurer*

The last meeting of the 1952–1953 season for the Cleveland-Akron Section was held on April 21 at Case Institute of Technology. The Pesco Pump Division of Borg-Warner Corporation was the industrial sponsor.

The election of officers for the 1953–1954 season was held. The results are as follows: Chairman, E. C. Sulzman; Vice-Chairman E. J. Manganiello; Vice-Chairman (Akron Division), J. W. Ebert, Jr.; and Secretary-Treasurer, R. T. Hall. The Members of the Council are: Morris A. Zipkin; R. E. Bolz; E. R. Sharpe; L. A. Rodert; Abe Silverstein; Sam S. Mullin; A. T. Colwell; and G. P. Welty.

The main speaker of the evening was H. S. Tremper, Military Liaison Manager, Piasecki Helicopter Corporation, who spoke on "Military Applications of the Helicopter." Mr. Tremper gave many details of present and future designs of helicopters and discussed their multitude of uses in transportation, ship unloading where docks are unavailable, rescue work, antisubmarine work, etc. His talk was followed by a 30-min. movie, which illustrated the many features the speaker had previously discussed. A stimulating question-and-answer period followed.

The meeting was attended by about 100 people for both the dinner and the technical session.

Columbus Section

▸ **The fourth dinner meeting** of the 1952–1953 season was held at the Officers' Club, Naval Air Station, Port Columbus, Ohio, on the evening of March 26. Approximately 70 members and guests attended.

The business phase of the meeting was opened with the reading and approval of the previous minutes. The Executive Committee reported that a nominating committee, consisting of representatives from North American, The Ohio State University, and Battelle Memorial Institute, has been appointed to consider Section officers for the coming year. Nominations from the floor will be received at the next meeting. Balloting will be carried out by mail. The Executive Committee further reported that any forthcoming lack of a speaker will not keep us from holding a scheduled meeting. Efforts will be made to fill in out-of-town speaker cancellations with local speakers whenever possible; however, in the event that no speaker is available, a purely social meeting will be held. Commander A. L. Petitjean reported that the Columbus Technical Council has opened its drive for contributions to its building fund and is asking for pledges. The Council is establishing an organization to handle the funds collected. Commander Petitjean should be contacted for pledge cards.

The joint speakers of the evening were Morgan M. Blair, Chief Aerodynamicist, North American Aviation, and James Denniston, Supervisor, Surface Controls Group, North American Aviation, who spoke on the subject "Power Control Systems for Airplanes—Why and How." Mr. Blair began by explaining that the problem of control-force reduction in air planes has been an ever increasing struggle because of the large increases in airplane size and maneuverability in recent years. Initially, force reductions were obtained by increasing mechanical advantage. This was followed by the use of aerodynamic balance and trailing-edge tabs to reduce the control-surface hinge moments. On large airplanes traveling at high speeds, a point was reached where sufficient control force reduction could no longer be obtained by these methods. This problem was solved by addition of a "load-feel" hydraulic control system that supplies an aiding force proportional to the pilot effort. Such a system can effectively be used to reduce the required pilot effort by a factor of 10. When boost ratios somewhat greater than 10 are used, the added complication of an emergency boost system must be considered to ensure reasonable forces in case of primary boost failure. As sonic speeds are approached, control effectiveness is greatly reduced, thus requiring more control-surface deflection. This, coupled with the effects of compressibility on hinge-moment characteristics, can require boost ratios of 50 to 100 to obtain satisfactory control forces. North American's approach to the problem of sonic flight on the late FJ-2-type airplanes has been an "irreversible" power control system that supplies the total force required to move the control surfaces. "Feel" for the pilot is supplied by a bungee spring and a bobweight, making control force proportional to control deflection and normal acceleration. Mr. Denniston described in detail the mechanical and hydraulic aspects of the FJ-2 control systems. Types of control valves and the limitations of each were discussed. The conclusion drawn was that the "irreversible" type of power control system described was one of the most practical yet developed in that it is simple in operation, trouble free, and lightweight. The lecture was illustrated by slides and followed up by a

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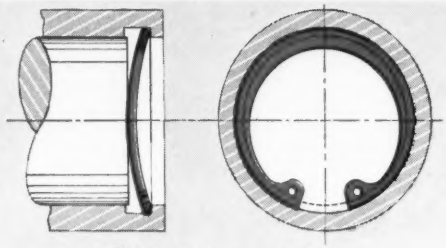

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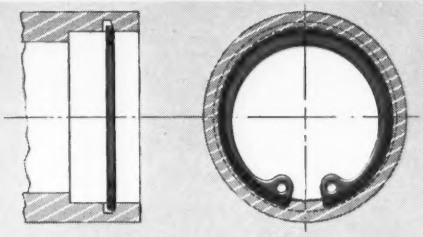

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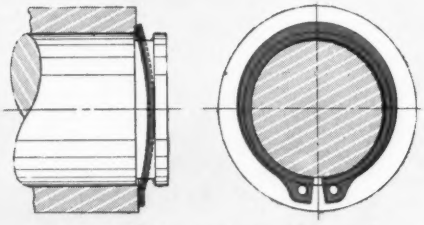

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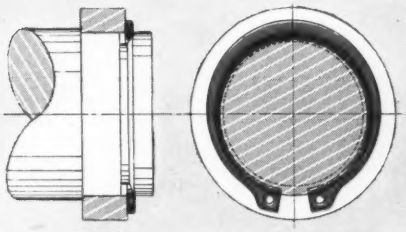

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demonstration of the control system in operation on a full-scale working mock-up. The meeting was closed at approximately 10:30 p.m.

P. V. Titus, *Acting Secretary*

▶ **The fifth dinner meeting** of the season was held at the Officers' Club, Naval Air Station, Port Columbus, Ohio, on the evening of April 29. Approximately 45 members and guests were in attendance.

The business phase of the meeting was opened with the reading and approval of the previous minutes. The Nominating Committee reported on its slate of officers for the next year, and, since no further nominations were secured from the floor, the ballot as presented was considered approved. The election of officers will be made by mail and results reported at the next meeting.

A. G. Winnett, Jr., opened a discussion on the possibility of limiting meetings to members of the IAS only. After some discussion, Art Tifford made a motion to charge an unspecified amount for nonmembers to attend each meeting. M. M. Blair seconded the motion, which was carried unanimously.

Mr. Tifford announced the program for the next meeting, which will be held on May 27, 1953. The speaker will be R. M. Woodham, from Cornell Aeronautical Laboratory, Inc., who will speak on "Air Safety."

Mr. Tifford then introduced the speaker of the evening, F. A. Hitchcock, Professor of Physiology, The Ohio State University. Professor Hitchcock discussed space travel from the biological point of view. He pointed out the environmental problems that might be encountered in space travel and discussed these problems in terms of the requirements for survival. He suggested a rather novel solution to the problem of maintaining adequate oxygen supply inside a space ship through the use of flora. If enough living plants were provided, they would furnish a steady oxygen supply. Probably the best type of plant would be those known as algae, which supply a high rate of oxygen and, at the same time, could be eaten by the crew. Other problems such as temperature control, pressure control, additional food and water, and protection from cosmic rays could be solved without too much difficulty. The problems of the gravity-free state and body orientation would require some study if the condition would have to be sustained for a great length of time. Professor Hitchcock pointed out that the construction of a space ship would represent a great industrial and economical advancement, because such a development

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would open up almost fantastic scientific possibilities. The question period was quite active, and Professor Hitchcock's talk was considered both interesting and informative. The meeting was adjourned at 10:30 p.m.

S. A. Gordon, *Secretary*

Los Angeles Section

Harold S. Fischer, *Secretary*

"Ram-Air Turbine Driven Auxiliary Power Units for Missiles" was discussed by Edward I. Brown, Project Engineer, Marquardt Aircraft Company, at a Specialist Meeting held on April 9 at the Los Angeles Institute Building. An audience of 65 heard Mr. Brown discuss methods of producing hydraulic and electric auxiliary power in missiles that do not contain a rotating engine. In comparing energy sources, he indicated that ram-air turbine driven accessory systems have distinct advantages in respect to weight, space, and shelf life over other systems.

▶ The monthly dinner meeting on April 16 featured Roy Marquardt, President of Marquardt Aircraft Company, speaking on "Tomorrow's Power Plant Today." Mr. Marquardt traced the development of power plants from the time of Hero's "Aeolipile" in 100 B.C., which was the first experiment leading to the development of steam power. A model of this device was displayed. Listing the thermal efficiency, specific fuel consumption, and other characteristics of various power-plant types in history, Mr. Marquardt indicated that the horse was one of the most efficient power plants known until the advent of the ram-jet.

The application of ram-jets to missiles and other aircraft was the principal topic discussed. Several ram-jet and accessory items were exhibited. Also on display was a replica of the engine that powered the first Wright Brothers airplane, constructed by a group of Marquardt Company employes.

Mr. Marquardt concluded with the following prediction: "It is my opinion that in 20 years the ram-jet will be used extensively as a primary power plant for long-range commercial aircraft sweeping across the country at speeds of 2,000 m.p.h. . . ."

▶ On April 23, a Specialist Meeting was held with Dr. Z. O. Bleviss, Aerodynamics Engineer, Douglas Aircraft Company, Santa Monica, Calif., speaking on "Some Aerodynamic Effects of Streamwise Gaps in Low Aspect Ratio Lifting Surfaces at Supersonic Speeds." The configuration considered was a flat half-delta wing adjacent and normal to a vertical wall. The effect of gap on the spanwise lift distribution, lift, center of pressure, drag due to lift, and vorticity at the trailing edge was shown. Wing characteristics as a function of gap size, Mach Number, and leading-edge sweep were given. Effects of a gap on wing-tail interference and on the strength and initial positions of the rolled-up trailing vortices were discussed.

▶ Because of the great popularity of the plant inspection trip to the Aluminum Company of America plant at Vernon, Calif., attended in 1952 by more than 200 Los Angeles Section IAS members, a second inspection trip was held on April 22. Approximately 300 IAS members attended this repeat performance, which proved again to be extremely interesting. Alcoa staff guides escorted groups of visitors through the foundry, extrusion plant, tube mill, forge shop, forging die shop, rivet plant, and testing laboratory.

San Diego Section

E. R. Hinz, *Secretary*

A joint dinner meeting with the Associated Glider Clubs of Southern California was held in the Institute of Aeronautical Sciences Building in San Diego on March 12. The speaker for the evening was William S. Ivans, holder of the International Absolute Altitude and Altitude Gained records for soaring of 42,100 ft. and 30,100 ft., respectively.

Bill Ivans described the factors that govern cross-country soaring. He outlined the atmospheric conditions that are conducive to cross-country soaring and the soaring techniques that have resulted in the new distance records of the past few years. Some of the newer glider designs were discussed, and the characteristics that affect their soaring performance were analyzed. The talk was illustrated with slides and colored movies of soaring meets and cross-country flights.

▶ On March 28, a field trip was made to the U.S. Navy's Border Field to observe the operation of aircraft target drones. A conducted tour was made through the various shops that service the drones; here, the construction and operating details of several pilotless aircraft types were described. The highlight of the morning trip was a launching and flight of a Globe pulse-jet-powered target airplane. The operator controlled the drone through a hand-held "black box" and put the model through paces that rivaled its full-scale piloted counterparts. A parachute retrieve of the drone was accomplished, after which the observers had an opportunity to inspect it again.

All members present agreed that this little-publicized phase of aviation was well planned and engineered and certainly fascinating.

▶ The monthly dinner meeting was held on April 2 in the IAS San Diego building. A "dual-speaker" program was arranged on the subject of "Aircraft Anti-Icing." Presenting the engineering aspects of aircraft anti-icing was Victor Hudson, Senior Thermodynamics Engineer at Consolidated Vultee Aircraft Corporation. The air lines' experiences with anti-icing equipment were presented by Capt. C. M. Christenson, Director of Safety for United Air Lines, Inc.

Vic Hudson summarized the mathematical analysis of icing on which current anti-icing equipment designs are based, including the effects of atmospheric temperature, water droplet size, shape of the aircraft surface concerned, and the aircraft's speed. Aerodynamic heating of aircraft surfaces at high flight speeds was shown to be insufficient to prevent or control aircraft icing. Test facilities to evaluate anti-icing equipment were described; these included icing wind tunnels, a test station atop Mount Washington in New Hampshire, and aircraft flight tests. Slides were shown to illustrate this engineering phase.

Captain Christenson, discussing the air lines' approach to icing problems, emphasized the air lines' objective to maintain flight schedules and maximum safety simultaneously. Therefore, they must be prepared to combat icing at any time. Pilots are trained in methods to prevent or control formation of ice on the aircraft by proper utilization of the aircraft's anti-icing equipment. Where severe icing conditions are known to exist, flight plans are altered to fly over or around the dangerous area. One of the little-publicized icing problems which can seriously disrupt scheduled operations is that of ground icing. Airplanes parked in the open at terminals can collect very heavy deposits of ice during sleet conditions; this requires that the aircraft be brought into a hangar and warmed to remove the ice. Captain Christenson also discussed icing research by United Air Lines and many of the air line's experiences in these studies.

Seattle Section

Alvin J. Jarvis, *Secretary*

The April 23 meeting of the Seattle Section was held at the Sand Point Naval Air Station's Officers' Club.

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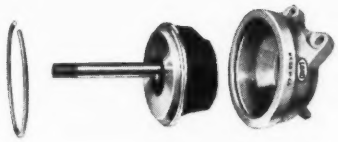

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Prater Hogue, Airworthiness Engineer, Boeing Airplane Company, spoke on the subject of crash investigation. The slide-illustrated lecture was impressive and was well received by the audience numbering approximately 100.

Mr. Hogue served for $1^1/_2$ years as Boeing representative to the Air Force at Norton AFB, San Bernardino, Calif., in crash investigation and has done investigation work on civil air crashes for the underwriters.

"Most crashes," Mr. Hogue observed, "are not the result of a single malfunction or error, but evolve as a result of a sequence of malfunctions and errors." Several instances of such crashes were quoted as examples.

The need for simplicity of systems operation with definite differentiation in systems controls was stressed as an important step in crash prevention. "Many crashes attributed to pilot error are actually attributable to design error," stated Mr. Hogue, "since the crashes were designed into the airplanes and required only the proper set of circumstances to bring them about."

The talk, coming on the heels of two nonscheduled air-line crashes in the immediate vicinity within the previous week and one Boeing KC-97 crash a short distance from Seattle the same day, was noteworthy also for its timeliness. Unfamiliarity of the pilot with terrain and weather peculiar to the locale was pointed up as the deciding element in many northwest United States and Alaska crashes.

"Crashes from flight of present-day high-speed aircraft impose severe problems in determining cause," said Mr. Hogue, "since there is so little left of the aircraft to substantiate assumptions."

After the talk, Mr. Hogue answered questions put by the audience.

Texas Section

Howard F. Marx, *Secretary*

"The Buckaroo Becomes a Tactical Weapon" was the theme of the April 16 dinner meeting of the Texas Section at the newly redecorated Officers' Club at the Dallas Naval Air Station. The speaker was H. Gus Erickson, Chief Engineer of Temco Aircraft Corporation. Mr. Erickson traced the development of the Buckaroo from its predecessor, the Temco Swift, to the present tactical model with machine guns and rockets.

Originally, three Buckaroo trainers were built for evaluation by the USAF. Mr. Erickson discussed the "growing pains" experienced in modifying the basic Swift design to that of the Buckaroo. Stalling at the wing-fuselage junction produced objectionable tail buffeting; a well-designed wing-root fillet eliminated this difficulty. The airplane also exhibited negative static longitudinal stability; good control characteristics were obtained by using the combination of a bob-weight and an elevator antiservo tab to give the minimum stick force per *g* specified by the USAF.

The development of the Buckaroo as a tactical airplane began with a request by the Philippine government for 500 light airplanes with guns. Although this particular contract was not completed, Temco did install 50-cal. machine guns that were manually charged and electrically fired. Better than normal accuracy was achieved by the Buckaroo in firing tests. The effectiveness of the Buckaroo as an aerial rocket launcher was also demonstrated using ten 2.25-in. practice rockets.

Foreign countries interested in the export version of the Buckaroo include Thailand, Israel, Arabia, and Chile. Mr. Erickson outlined the advantages of the light tactical airplane as: (1) The airplane may replace conventional artillery, thus eliminating the large supporting troops, observation posts, etc., required for regular artillery. (2) This airplane is ideal for eliminating

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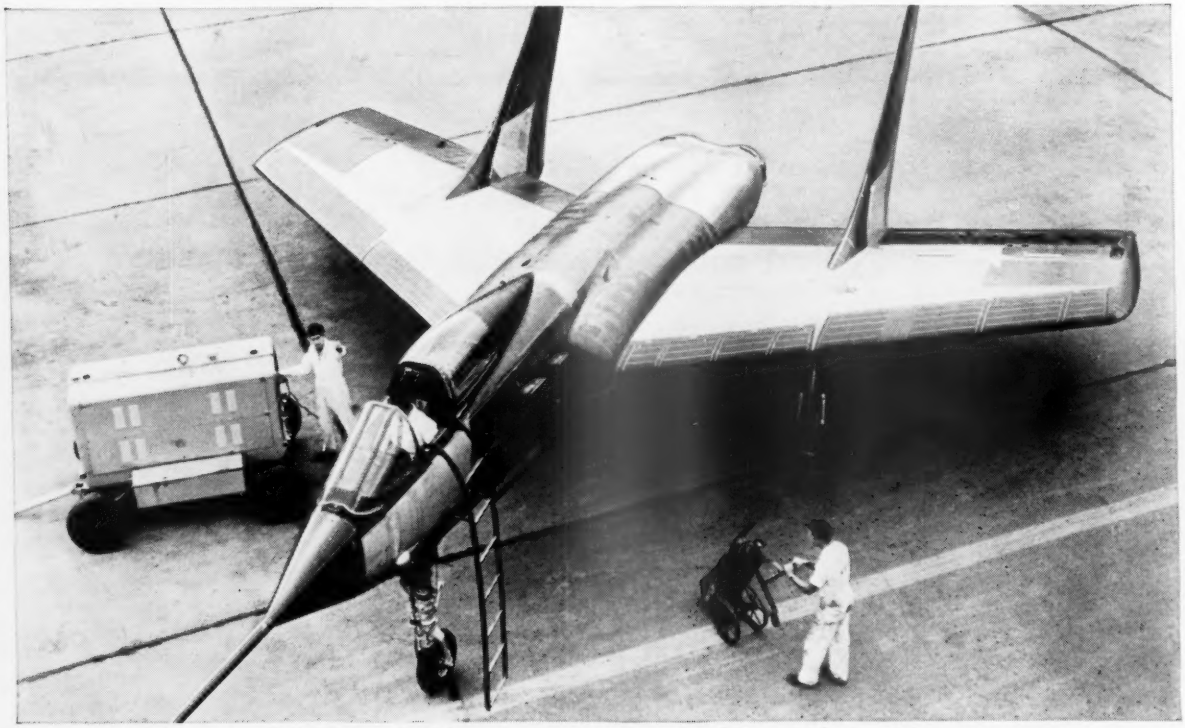

In this view of the F7U-1 Cutlass, the dark metal areas are magnesium, the light areas aluminum. The same extensive use of magnesium is made in the F7U-3. Not seen, but made of magnesium, are landing gear fairings and engine access doors.

Building planes that will fly greater distances without refueling is a challenge faced by the modern aircraft maker. To solve this problem many manufacturers use lightweight magnesium which lets them take on extra fuel and other equipment in place of the heavier metals originally used on aircraft.

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enemy liaison-type light planes, in that regular high-performance airplanes are unable to shoot down liaison types because of poor turning performance at low altitudes.

Mr. Erickson spoke briefly about safety features. The starter was especially praised. "If you lose an engine on a T-35 Buckaroo, just kick the starter and you will have enough power to get back home," he said.

After movies of the Buckaroo in action were shown, the meeting was adjourned.

Toronto Section

R. T. Gibson, *Secretary*

The March 19 meeting of the Section took the form of a joint meeting with the Toronto Branch of the Engineering Institute of Canada, and J. T. Dyment spoke on "Current Trends in Design of Airline Transports." Mr. Dyment, who is Director of Engineering for Trans Canada Airlines, has enjoyed a varied career in aviation. As a member of the RCAF reserve, he learned to fly while attending the University of Toronto. After receiving his degree in Mechanical Engineering in 1929, he spent a number of years in the aircraft manufacturing field, before joining the Civil Service of Canada. In this position his duties included the stress analysis of civil aircraft. He joined T.C.A. in 1939, shortly after its formation.

Stating that air transport has made greater gains in the past 10 years than in any other period of equal length, the speaker stressed the improving safety factor and the benefits derived from military developments. These include larger aircraft with greater range and speed. Of equal importance are the electronic advances in automatic flight and landing procedures.

In predicting future developments, Mr. Dyment expressed the view that turbine-powered transports, now entering the picture, would be in far greater use in the early 1960's, when engines having better fuel consumption would be available. He felt that atomic-powered transports for very long-range service were not too far away, while the helicopter will prove to be the answer for short-range operations.

▶ On April 22 a joint meeting with The Toronto Gliding Club was held, when Paul Schweizer, of the Schweizer Corporation, Elmira, N.Y., spoke on "The Engineering Aspects of Sailplane Design and Flight." In introducing the guest speaker, J. W. Ames outlined briefly his activity in the gliding field, which goes back to his boyhood days. Mr. Schweizer is now proud possessor of the Gold Pin with Diamond, awarded by the Fédération Aéronautic Internationale.

The speaker touched briefly on the achievements in the gliding field, which now include record flights to a height of 44,000 ft., an endurance of 56 hours, and a distance of 545 miles. He referred to gliding as a research tool—a chance to try out new ideas at comparatively little expense. Tricycle undercarriages, stressed skin construction, and enclosed cabins were first tried on gliders.

Pointing out the glider design requires allowance for the pilot's skill to a greater degree than for powered flight, Mr. Schweizer went on to outline the four periods in glider development. He traced its growth from the early primitive types, through the low-sink sailplane and thermal soaring stages, to the higher-speed cross-country craft of today.

The meeting concluded with a showing of excellent color slides, taken by Mr. Schweizer at the 1952 U.S. National Contest in Texas and at the 1952 International Contest in Spain.

Twin Cities Section

Wesley J. Fisher, *Secretary*

The Twin Cities Section held several interesting meetings.

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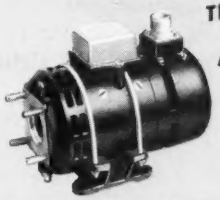

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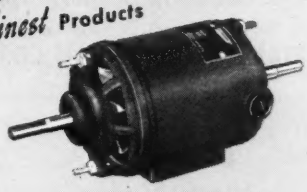

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▶ On February 19, a tour was made of the facilities of Federal Aircraft Works, of Minneapolis. An inspection of the company's products, such as the latest gear for helicopters, was enjoyed by the members. The meeting was concluded with films showing various tests of aircraft skis made in the Arctic regions.

▶ On March 26, Ronald M. Hazen, of General Motors Corporation's Allison Division, spoke at the Twin Cities dinner meeting on "The Operation of the Jet Engine." A lively question-and-answer period was held at the close of Mr. Hazen's informative talk. There were 94 persons in attendance at this meeting.

▶ On April 8, Reeves Morrisson, of Pratt & Whitney Aircraft Division of United Aircraft Corporation, spoke on "The Modern Gas Turbine." The advantages and disadvantages of the gas-turbine engine for aircraft were discussed. This meeting was held jointly with the local section of the Society of Automotive Engineers.

Washington Section

Capt. Paul J. Burr, USN, *Secretary*

The meeting of April 7 was held at the Natural History Museum at 8:00 p.m. It had been preceded by a dinner at the Hotel Burlington at 6:00 p.m.

The meeting's theme was "Aviation Safety Night." The Honorary Chairman, William Littlewood, Vice-President of American Airlines, Inc., introduced the following speakers and their subjects:

Jerome Lederer, Director, Flight Safety Foundation—"Current Level of Aviation Safety."

T. L. K. Smull, NACA—"NACA Research to Improve the Safety of Aircraft Operation."

Frank Brady, Air Transport Association—"Aircraft Collision Prevention."

David Posner, CAA—"Some Efforts to Improve Crash Survival."

Mr. Lederer in his talk outlined the philosophy of safety. He pointed out its importance in a democratic economy—that it is our concern for safety that distinguishes men from animals and intelligence from ignorance and that the physical welfare of our fellows is dignified by safety considerations as the Constitution dignifies our individuality. Evidence of the positive trend for improved safety records was shown through the use of slides. The fact that one can buy $5,000 worth of insurance on the scheduled air lines for only $0.25 means that the calculated risk is one chance in 50,000 to 70,000. The entry of three competitive insurance companies into

this field in recent years would make it apparent that this kind of policy selling is a profitable business.

The speaker pointed out that the statistics on agricultural, business, and military flying show a definite need for increased safety. There are, however, reasons why these three types of flying cannot be so safe. Mr. Lederer described the efforts to improve safety made by the industry as well as by Flight Safety Foundation and the Cornell-Guggenheim Aviation Safety Center. Both the Foundation and the Center are operating to effect a reduction in accident frequency through education and information dissemination.

Mr. Smull, the second speaker, outlined the NACA research program for safety, which is under the direction of a committee on Operating Problems. This program includes: meteorology, icing, fire prevention, aircraft noise, and aircraft-accident survival. He discussed the more significant work being done in each of the above categories.

He told about the development of the NACA turbosonde, which is a radiosonde-type equipment for detecting and measuring turbulence up to 60,000 ft., and about the NACA VG recorders, which in the past 5 years have logged over 230,000 hours of flight time. Icing research, Mr. Smull continued, has evolved a technique known as cyclic-heat deicing, in which the actual heat required can be reduced as much as 20 times that required for continuous anti-icing. He also referred to the crash study program, wherein actual war-weary aircraft are crashed against an embankment to enable study of the effects of impact.

Mr. Brady in his paper on "Aircraft Collision Prevention" suggested, on the basis of official records, where expenditures of time and effort would be most profitable. It was interesting to note that the CAB records of collisions involving air-carrier aircraft from 1938 to 1952 listed 14 mid-air collisions. Twelve of these 14 collisions occurred during the daylight hours, the other two happening at night; 13 of the 14 collisions took place in VFR weather with only 1 occurring in IFR weather. He briefed us on a Cornell analysis of 1949 which indicated that 75 per cent of all collision near-misses occurred in the terminal areas; of this total, 66 per cent involved aircraft flying without traffic-control clearance and another 44 per cent involved aircraft flying in IFH or marginal VFR weather.

Mr. Brady outlined suggested improvements in electronic equipment and traffic-control procedures designed to reduce collisions. He summarized his recommendations as follows: (1) require two-way radio for all aircraft operating in high-density areas; (2) make maximum use of airport surveillance radar and provide for control of all aircraft in the terminal area in both IFR and VFR conditions; (3) use airplane speed control in high-density terminal area; and (4) encourage the use of high-intensity flashing lights on all aircraft.

Mr. Posner, the fourth and last speaker of the evening, gave an interesting approach to aviation safety by taking a look at the possibility of designing "crash-safe" airplanes as against crash prevention. He pointed out that in spite of superior design aimed at eliminating crashes, these crashes will still occur and that fatalities can be reduced by attention to details that will permit personnel to suffer crashes with better chances of survival. He emphasized that protection of personnel, by aircraft, during crashes was already superior to that provided by other forms of transportation. In airplane crashes, fire resulting from a crash was the biggest killer.

Mr. Posner's recommendations for improved chances of survival during crashes included: (1) externally located fuel tanks; (2) fuel tanks designed for increased crash resistance (200 "g" tanks have been built and tested); (3) consideration of the British impact-actuated devices to initiate fuel shutoff and fire-extinguisher systems automatically; (4) provision of better evacuation procedures and equipment to control evacuation and to eliminate needless evacuation accidents, particularly in those cases where fire does not result and sufficient time for evacuation does exist; and (5) recognition of the hazard created by continued operation of jet engines after a crash in which the engines, unlike their propeller-driven counterparts, do not necessarily stop functioning but must be shut off by the crew.

This meeting also included the annual business of the Washington Section. Chairman J. H. Sidebottom conducted a short business meeting in which the Section's Constitution and By-Laws, previously distributed to the Section members, were approved with only a minor change. Mr. Sidebottom then introduced the new officers of the Section, who are: Chairman, Capt. W. C. Fortune, USN; Vice-Chairman, William L. Greene; Secretary, Thomas C. Muse; Treasurer, Lt. Col. Lloyd F. Ryan, USAF; Advisory Board Members, Brig. Gen. D. J. Keirn, USAF, and Rear Adm. Calvin M. Bolster, USN; and Section Representative on the Nominating Committee for Area Councilors, Milton B. Ames.

Student Branches

Academy of Aeronautics

Kenneth O'Connor
Corresponding Secretary

On April 15, IAS Student Member Richard Kita delivered a paper on the "Application of Jet Propulsion to Helicopters." In his talk, he compared the relative efficiencies of the ram-jet, pulse-jet, and reciprocating engines when used in helicopters. He judged that jet-propelled helicopters would be in mass production in the not-too-distant future. A film from North American Aviation, Inc., *This Is Airpower*, concluded the program. Chairman George Ludwig presided; 55 were present.

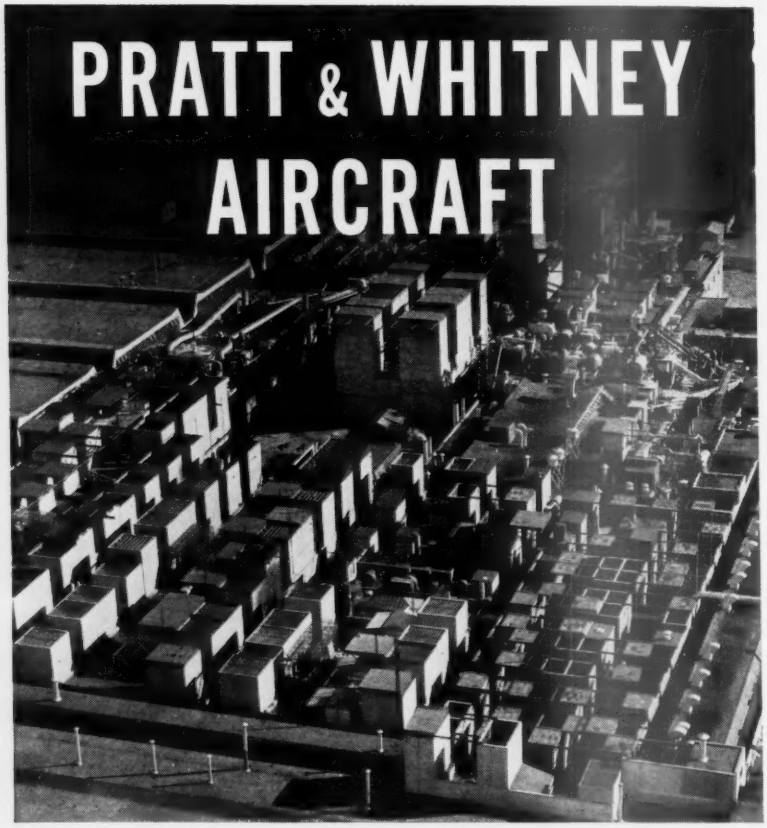
▶ On April 29, a field trip of May 14 to Curtiss-Wright Corporation was discussed. Two films were shown—one from The Glenn L. Martin Company entitled *PBM Wing Destruction Test* and the other from North American Aviation entitled *NAITV*. Chairman Ludwig presided; 55 were present.

Agricultural & Mechanical College of Texas

Ray Custer, *Secretary*

Immediately after the meeting of April 21 was opened by Chairman Arthur P. Goldberg at 7:30 p.m. with 15 persons present, the old business was discussed. Ray Lyons outlined the plans for the Open House Day Exhibits and requested that all members contribute their time and energy in making the Aeronautical Engineering Department's exhibits the best on campus. Wayne Sabo, Vice-Chairman, was appointed Chairman of the committee to plan this Student Branch's annual picnic, which will be the last meeting of the school year.

A student technical paper contest was held as a preliminary to the First Annual Student Paper Contest held May 6–9 by the Texas Section in Fort Worth. Four papers were presented in this preliminary contest: "Stability and Control at Stall" by



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S. A. Zobal; "A Discourse on Shock Waves" by T. M. Evans; "A Rocket to the Moon" by T. Perkins; and "The Nature of Super Aerodynamics" by J. M. Firebaugh. The judges selected Messrs. Zobal and Firebaugh to represent the school at the Texas Section's contest. Mr. Evans and Mr. Perkins were awarded consolation prizes of $15 and $10, respectively.

The chairman adjourned the meeting at 9:45 p.m.

The Catholic University of America

William G. Elsen, *Secretary*

The meeting of April 29 was divided into two parts, the first being held in the morning and the second being held in the evening. At the morning session, new officers were elected for the coming academic year. William Elsen, who will be a senior next year, is the new Chairman, while the positions of Secretary and Treasurer will be filled by Kob Kastner and Ben McMullen, respectively. This short morning session was adjourned when the elections and the presentation of a business report were completed.

The newly elected Chairman presided at the evening session of the April 29 meeting. Seventeen members were present.

The guest speaker on this occasion was J. G. Kayten, of the Navy's BuAer, who gave a talk on "Military Aircraft Specifications." Mr. Kayten outlined the historical development of the military's requirements for aircraft manufactured by private industry. He then gave specific examples of the types of specifications now issued by the Air Force and the Navy to aircraft manufacturers. After the talk, there was an informal question-and-answer period, during which refreshments were served.

Iowa State College

Gary Bowman, *Secretary*

At the March 4 meeting, the following persons were elected to office for the coming year: Chairman, Marvin Shulenberger; Vice-Chairman, David Rogers; Secretary, Gary Bowman; and Treasurer, John Dennison. The Junior and Senior Representatives to the Engineering Council are Allen Grandfield and D. Philip Smith, respectively. Dean Strief was named Program Chairman. The Honorary Chairman of the Iowa State College Student Branch is Dr. Glenn Murphy.

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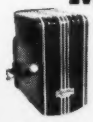

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1945 South Wind Model 920, 100,000 BTU/hr.

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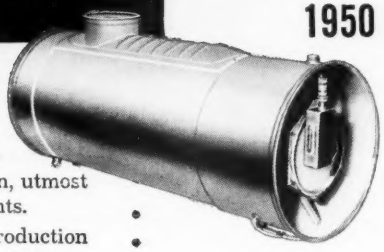
1949 South Wind Model 910, 235,000 BTU/hr.

1949 South Wind Model 929A, 700,000 BTU/hr.

1950 South Wind Models 995, 996, 999, Inert Gas Generators



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Piper Corporation

Mississippi State College

Thomas C. Pope, *Secretary*

On April 13, the IAS Student Branch at Mississippi State was privileged to have as its guest speaker, Prof. Itiro Tani, of the Institute of Aerodynamics, University of Tokyo.

Professor Tani, who was introduced by Dr. August Raspet, of Mississippi State's Aerophysics Department, spoke on "The Development of Laminar Airfoils in Japan." In his lecture, the speaker covered the methods of experimentation, the applications made, and the results of his study of laminar airfoils. Professor Tani also made a thorough comparison between the results that he had obtained and the results that had been obtained from similar NACA research.

Following Professor Tani's talk, a brief and interesting discussion period was held, after which the meeting was adjourned.

The Pennsylvania State College

Frank A. Leader, *Secretary*

A regularly scheduled meeting was held on April 15 with 35 members attending. Chairman Max Schuster presided.

During the meeting, an election of officers was held with the following results: Chairman, Frank A. Leader; Vice-Chairman, Emil Kaegi; and Secretary-Treasurer, Ralph N. Straley.

The film, *Bristol Brabazon*, was then shown. It depicted the planning and construction of the Brabazon from the beginning to the end and also showed the facilities for taking care of such a large aircraft.

Syracuse University

Charles E. Rogers, *Secretary*

The March 30 meeting was opened by Chairman Fred Boenig with 13 members and the Faculty Adviser, Joseph Cady, present. The minutes of the previous meeting were read and approved.

The Plaque Committee reported that it is still working on the dedication arrangements.

A motion was carried to have a joint spring picnic with Pi Tau Sigma, the mechanical engineering honorary. The Picnic Committee consists of Dave Birdseye, Bob Mack, Ed Phillips, and Charles Rogers.

The annual spring field trip to an aircraft plant was brought before the group with discussion as to which one the members would like to visit.

The Program Committee announced future plans. Films are obtainable from the AFROTC and Piasecki Helicopter Corporation.

All members were urged to attend the annual engineering banquet to be held Saturday, April 18.

The guest speaker of the evening was William Peck, Piasecki Helicopter Corporation. Mr. Peck enlightened the members on the corporation and a few of the problems of helicopter work. Brought out in a question period were the future plans of the corporation and the applications of helicopters to commercial flying.

A film entitled *How To Fly The B-25* filled the remainder of the program.

▶ The April 22 meeting was opened by Chairman Fred Boenig with ten members present. The minutes of the previous meeting were read and approved.

Dedication of the Robert Ostrander Memorial Plaque has again been delayed. Robert Mack, Committee Chairman, has been unable to obtain a dedication date from university officials.

Plans for the spring picnic are now to embrace the IAS, Pi Tau Sigma, ASME, and SAE. It will be held May 9. The picnic site will be announced at the next meeting. From 16 to 20 members are expected to represent the IAS. An invitation is to be extended to the faculty members of the Aeronautical Department.

Material pertaining to films available and student awards was read to the members. Plans will be made as soon as possible to get an Award Committee in operation.

Election of officers for the fall semester will take place at the next meeting.

Tri-State College

Thomas D. Owens, *Secretary*

The first meeting for the spring quarter was called to order by the Chairman, Douglas Binnington, on March 26. It was held in the Aeronautical Laboratory to introduce the new students to the facilities available to them.

Lists were made available for the members to sign for membership in the Glider and Model Clubs, for free instruction in the Link Trainer, and for field trips to Wright Air Development Center and North American Aviation, Inc., in May.

Professor Quinton Hawthorne, Honorary Chairman, gave a short talk on the organization of the IAS and the advantages of being a member.

After the meeting was adjourned, the 29 members present were served coffee and doughnuts.

▶ The spring-term banquet was held at the Captain's Cabin, Crooked Lake, Ind., on April 9. Because of the unexpected illness of our Chairman, Douglas Binnington, Vice-Chairman Donald Monroe was the Master of Ceremonies.

Professor Hawthorne introduced the speaker, Frederick Steele, Assistant Project Engineer, McDonnell Aircraft Corporation. The title of Mr. Steel's talk was, "What can the graduate engineer expect in industry?" He closed with a question-and-answer period to which the members readily responded.

University of Alabama

Curtis G. Harvey, *Secretary*

The meeting of March 31 was called to order at 7:30 p.m. by Chairman Shannon Williford.

Plans for the Engineering Open House were presented and discussed; various members were assigned the job of procuring exhibits for the day. Plans were formulated for the trip to Mississippi State College for the Fourth Annual Southeastern Regional Meeting on April 9, 10, and 11.

Professor C. H. Bryan gave an informal talk on the recent IAS Annual Meeting, which he attended the latter part of January in New York City.

The meeting was adjourned at 8:30 p.m.

▶ The meeting of April 21 was called to order at 7:30 p.m. by Chairman Shannon Williford. Twenty-three members were present.

Stanley A. Cook, Aerodynamic Project Engineer for The Glenn L. Martin Company, was the guest for the evening. He presented two films to the group. The first was the *Flight of the Viking*, which dealt with missile development and testing. The second film was on *Rough Water Landings of PBM Seaplanes*.

A third film, *The History of Helicopter*, was also shown at the meeting. This one covered the development of the helicopter from the visionary drawings of Leonardo da Vinci to the troop-carrying giants of today.

A discussion period followed in which Mr. Cook answered and discussed questions pertaining to The Glenn L. Martin Company's program, policies, and practices in the aircraft industry.

The meeting was adjourned at 8:40 p.m.

University of Detroit

John L. Shea, *Chairman*

The meeting of March 20 was opened by John L. Shea, Chairman.

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Speaking to the 40 attending freshman and sophomore students, the chairman pointed out that the purpose of the meeting was to acquaint the new students with the purpose, advantages, and general organization of the University of Detroit's IAS Student Branch. He also talked about some of the activities of the Student Branch, such as the Student Paper Contest sponsored by the Detroit Section of the IAS and the *Air Show* Branch paper published each semester.

K. E. Smith, Director of the University of Detroit's Aeronautical Engineering Department, was then introduced. Mr. Smith gave a short talk on the aims of the College of Engineering at the university and how the professional societies aid in achieving these aims. One point brought out by Mr. Smith was that, although the university was primarily interested in the technical education of the student, it was also interested in developing men who are willing and able to take on extra responsibilities. He concluded that the professional societies are responsible for a large part of this development.

Larry Goebel, a senior, then proposed a plan whereby each senior would act as student adviser for a group of 6 freshmen and sophomores. The purpose of the student adviser will be to acquaint the underclassmen with the facilities and faculties of the Engineering College, in general, and the Aeronautical Department, in particular. In doing this, tours are to be scheduled during which the Student Adviser will show the new students the equipment in the main engineering and aeronautical laboratories and introduce them to the members of the faculty.

▶ The March 23 meeting was opened by Chairman Shea with 30 members present. The first business discussed was the IAS Student Paper Dinner, which is to be sponsored by the University of Detroit this year. It was brought out that the dinner is to be held at the Rackham Memorial Building in Detroit on May 11. The next order of business was to set up a student-adviser system. All new members were asked to stand and identify themselves and were immediately assigned to a particular senior who was to be their adviser. At the end of the meeting, the students and advisers made arrangements for tours through the Engineering College.

Upon the completion of business, the guest speaker, Russell Menne, Chief Training Instructor, American Airlines, Inc., was introduced. Mr. Menne talked on safety and passenger comfort on the Douglas DC-6 transports. In the course of his talk, Mr. Menne described some of the safety devices used in case of malfunction of the superchargers that pressurize the aircraft's cabin. He thoroughly described the fire-control system employed in the DC-6 and the procedures used by the pilot in case of an emergency. As an illustration, Mr. Menne told how a pilot saved his ship and passengers by using these safety devices and, at the same time, descending from 18,000 ft. to the ground in 1.5 min. Mr. Menne's fine talk was followed by a lively question-and-answer session at which other interesting points were brought out.

The meeting was adjourned at 9:15 p.m., at which time a general "bull session" was held over coffee and doughnuts in the Union Room.

University of Michigan

Walter H. Fenning, *Secretary*

The fourth meeting of the spring semester was held on Wednesday, April 15, with Kirke W. Comstock as presiding officer.

J. W. Braithwaite, Assistant Chief Aerodynamicist at Marquardt Aircraft Corporation, spoke on "The Development of Ram-Jet Power." In his talk, Mr. Braithwaite, with the aid of slides, compared the ramjet with the other main types of air-breathing engines and also reviewed some of the problems encountered in the development of this type of engine.

After the lecture, refreshments were served to the 35 members present.

▶ At the April 22 meeting, the attending students and faculty members heard two papers prepared for the student paper competition to be held in Detroit.

The first of these papers was presented by Albert W. Stohrer on "Calculations of Performance of an Ideal By-pass Jet Engine." In his paper, Mr. Stohrer compared such factors as thrust and fuel consumption of a turbojet and a turbo-ram-jet with his by-pass engine and explained some of the theory behind this type of engine.

The second of the papers was presented by Gerald Martius on "Human Effects of High Speed and High Altitude Flight." In this talk Mr. Martius discussed the psychological and physical effects of such hazards as low pressure, high temperatures, escape measures, and high speed on the human pilot.

After both talks were finished, the students decided to send Mr. Stohrer as our representative to the Detroit competition.

▶ At the April 30 meeting, Walter Doll, Technical and Research Engineer at Pratt & Whitney Aircraft Division of United Aircraft Corporation, gave a talk on "Gas Turbine Development at Pratt & Whitney Aircraft." In his talk, Mr. Doll gave examples of the ways in which Pratt & Whitney overcame some of the obstacles in jet-engine development and, with slides, showed the installations used to solve these problems. After the lecture, refreshments were served to the 31 members present.

University of Texas

James B. Kyser, *Secretary*

The University of Texas Student Branch met on March 9 with 26 members present. Chairman Jack Fairchild presided. (The other officers for the spring semester are: Vice-Chairman, Lawton Blalock; Secretary, James B. Kyser; and Treasurer, Bernard Minor.)

Among the things discussed at this meeting was the Power Show, which is to be held on May 8 from 5 to 11 p.m. Mr. J. W. Dalley, Faculty Adviser, reported that 15,000 visitors were expected and that invitations had been sent out to 1,150 high schools throughout the state. The IAS displays at the Power Show will be: (1) scale-model aircraft; (2) supersonic and subsonic wind tunnels; (3) dynamic display; (4) CO_2-powered jet models; (5) photoelasticity display; (6) jet-propelled helicopter; (7) movies; and (8) control model.

The program was then turned over to Lawton Blalock as Program Chairman. In this capacity, he introduced the topic, "New Developments in the Aircraft Industry," and the speakers, James M. Cooksie, Robert G. Voss, and James B. Kyser. Mr. Cooksie spoke on Laminated Glass and Plastics; Mr. Voss, on Titanium; and Mr. Kyser, on Sandwich Construction.

After the meeting was adjourned, coffee and doughnuts were served.

The University of Tulsa

Robert Wolfe, *Secretary-Treasurer*

The local IAS Student Branch was a cosponsor of the annual Tulsa University Engineering Open House on March 13. The school was open to the public for 5 hours. All of the engineering departments had various displays of interest on what they were studying.

The Aeronautics Department showed their laboratory and presented movies on current aircraft design. Specific points of interest in the laboratory were the dynamometer, wind tunnel, smoke tunnel, and various

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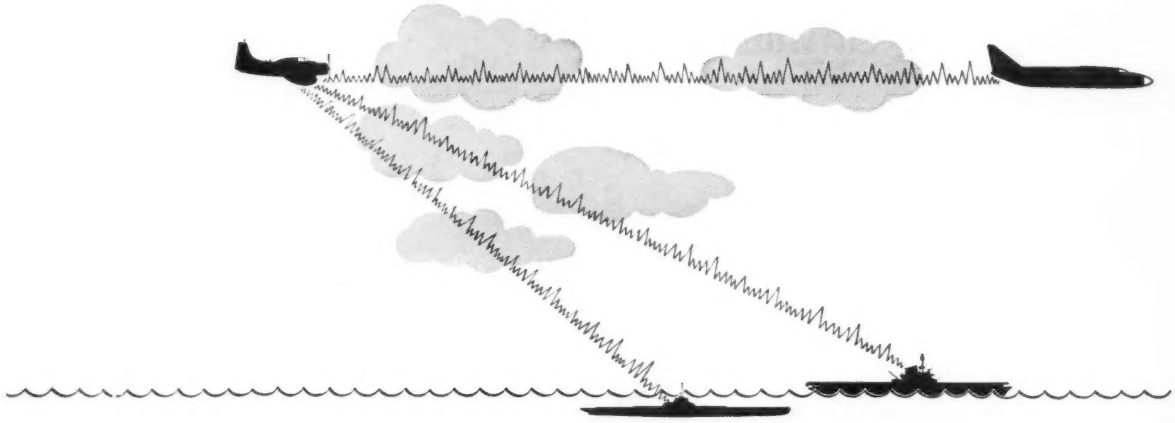

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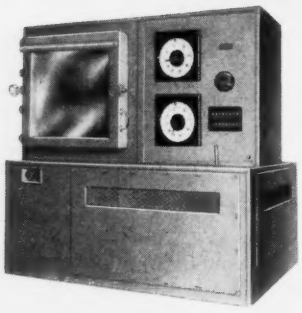

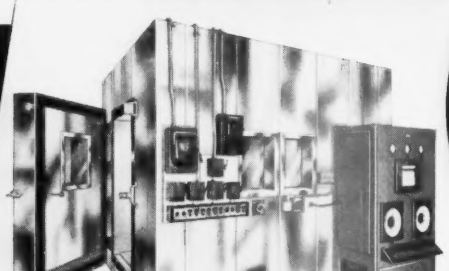

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engines. Also on display were the recently developed safety harness, perfected and displayed by the Beech Aircraft Corporation, and a large model of the DC-6 supplied by Douglas Aircraft Company, Inc.

All of the students were proud of their individual projects and pleased at the opportunity of showing the public just what they do in college and what the future holds for high school students entering engineering as a career.

▶ The meeting of March 19 was called to order by Vice-Chairman Keller. A film, *History of the Helicopter*, was shown, after which the minutes of the last meeting were read and approved.

Among the subjects discussed at this meeting was Tulsa University's participation in the IAS Texas Section's First Annual Student Paper Contest held during May at Fort Worth. A preliminary contest to determine the two students chosen to go to Fort Worth was scheduled for April 9. Four IAS students competed in the preliminary contest.

The meeting was adjourned at 9:00 p.m. by Chairman E. H. Roberts.

University of Wichita

Wilbur Middleton
Secretary-Treasurer

On April 10, a "send-off" meeting was held for the University's two delegates to the Texas Section's First Annual Student Paper Contest held in Fort Worth on May 6–9. Both delegates delivered the talks that they were to present during the competition. The delegates and their topics were as folllws: Pete Bernhard, undergraduate, "Turbulence and Wind Tunnels" and Harry Clements, graduate, "Effects of Power and Landing Gear on Static Longitudinal Stability."

In his paper, Mr. Bernhard defined and described turbulence and discussed the sources and effects of turbulence in a wind tunnel. Methods and advantages of reducing wind-tunnel turbulence were outlined.

Mr. Clements extended the reasoning followed in obtaining airplane $\partial C_m/\partial C_L$ coefficients to include landing gear and power contributions to static longitudinal stability.

Don Hufford, Chairman, presided; 16 persons were present.

U.S. Naval Postgraduate School

William D. Harkins, *Secretary*

At the April 8 meeting, the total attendance was 25. Lieutenant D. M. Layton, Chairman, presided.

Dr. Dean R. Chapman, of Ames Aeronautical Laboratory, NACA, Moffet Field, Calif., spoke on "Turbulent Skin Friction and Heat Transfer at Supersonic Speeds." In his lecture, Dr. Chapman showed the inadequacies of present-day theory in calculating skin-friction coefficients in a compressible flow. However, experiments have been rather extensive, and the engineer today has data available allowing him to predict skin-friction coefficients in flows of moderate Mach Number.

Various supplementary slides were also shown.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Transferred to Associate Fellow Grade

Lapin, Ellis, Ae.E., Aerodynamicist, Douglas Aircraft Co., Inc.

Elected to MEMBER Grade

Alksne, Alberta, B.A., Aero. Research Scientist, Theoretical Aerodynamics Sect., Ames Aeronautical Lab., NACA.

Barasch, Myles V., B.S.E.E., Staff Engr., Airborne Instrumentation & Control, North American Aviation, Inc.

Barish, Benjamin, B.S.M.E., Asst. Chief Test Engr., Frederic Flader, Inc.

Blumberg, Sam E., B.S., Product Engr., Vitro Corp. of America.

Breuer, Delmar W., M.S. in C.E., Asst. Prof. of Mechanics & Aircraft Struct., USAF Institute of Technology, Wright-Patterson AFB.

Brown, James E., Chief Engr., Aircraft Conversion Engineering Co.

Cochran, David, B.S. in M.E., Mgr.—Labs., Devel. Operation, Aircraft Gas Turbine Div., General Electric Co.

Evans, J. Gary, Jr., B.S.Ae.E., Stress Group Engr., Temco Aircraft Corp. (Dallas).

Graham, Harry M., S.M., Supvr., Power Plant Analysis, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Hastings, Donald F., B.S.E.E., Sr. Engr., Eclipse-Pioneer Div., Bendix Aviation Corp.

Hyatt, Frederick E., Jr., B.S., Chief Weight Engr., Republic Aviation Corp.

Kester, Robert H., M.Sc., Aero. Research Scientist, Ames Aeronautical Lab., NACA.

Kline, Stephen J., Sc.D.M.E., Asst. Prof., Mech. Engrg., Stanford Univ.

Knell, Kenneth A. J., D.I.C., B.Sc.-Eng., West Coast Rep., British Joint Services Mission.

Lebovits, Morris, M.S. in Aero., Aerodynamicist, Douglas Aircraft Co., Inc. (Santa Monica).

Lobb, R. Kenneth, Ph.D., Chief, Hypersonic Wind Tunnel Br., Naval Ordnance Lab. (Silver Spring).

McClellan, Cyril E., M.S., Mgr. of Electronics Engrg., Westinghouse Electric Corp.

McCourt, Andrew W., M.S., Supervisory Engr., Analysis Group, Air Arm Div., Westinghouse Electric Corp. (Baltimore).

Mouden, L. Homer, M.Sc., Pilot, Braniff Airways, Inc.

Murphy, Charles H. S., B.S.E.E., Comdr., USN; Bur. of Aero. Rep. assigned to McDonnell Aircraft Corp. (St. Louis).

Nakamura, Hideyoshi, M.S. in M.E., Thermodynamics Engr., Consolidated Vultee Aircraft Corp. (San Diego).

Nobles, Charles E., B.S.E.E., Sect. Mgr., Air Arm Div., Westinghouse Electric Corp.

O'Malley, James A., Jr., M.S.E.Ae.E., Proj. Aerodynamicist, Bell Aircraft Corp.

Ong, Charles M., Mgr., Experimental Lab., Jack & Heintz, Inc.

Purinton, Richard S., B.S., Dir. of Application Engrg., Air-Maze Corp.

Rose, Eugene S., Jr., M.S.Aero., Major, USAF; Devel. Div., Hq. FC, Armed Forces Special Weapons Proj., USAF, Albuquerque, N.M.

Russi, Michael James, M.S., Aero. Engr.-Group Leader, Ramjet Engine Devel. Sect., Marquardt Aircraft Co.

Schweizer, Ernest, B.S. in M.E., Pres. & Chief Engr., Schweizer Aircraft Corp.

Shafer, Guy C., B.S.M.E., Proj. Engr., General Electric Co. (Lockland).

Shumway, Howard H., Asst. Chief Flight Engr., Lockheed Aircraft Corp.

Stevens, James R., B.S. in Ae.E., Aerodynamicist, Aerodynamics Sect., Devel. Group, North American Aviation, Inc. (Los Angeles).

Teeter, George H., B.S. in E.E., Sr. Aerophysics Engr., Convair (Ft. Worth).

Trekell, Harold E., B.S.E.E., Mgr., Aircraft Instrument Engrg., Meter & Instrument Dept., General Electric Co. (Lynn).

Turner, Curtis L., Jr., B.S.Ae.E., Airframe Designer, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Werth, Albert A., B.M.E., Preliminary Design Engr., Fairchild Engine & Airplane Corp. (Hagerstown).

Wilkinson, Orville L., Sales Engr. (Hytrol), Hydro-Aire, Inc.

Transferred to MEMBER Grade

Anderson, John J., Major, USAF; Officer in Charge, Armament Dir., Flight Test Br., Armament Directorate, Hq., ARDC (Baltimore).

Curtis, Frederick A., Jr., M.S. in Aero., Sr. Aerophysics Engr., Consolidated Vultee Aircraft Corp. (Ft. Worth).

Heaton, Thomas R., M.Sc. in Ae.E., Proj. Engr., Turbine Aerodynamics Br. Compressor & Turbine Research Div., Lewis Flight Propulsion Lab., NACA.

Racisz, Stanley F., B.S.Ae.E., Aero. Engr. GS-11, NACA, Langley AFB.

Vaccaro, Robert J., M.S., Research Asst., Aero. Engrg. Dept., New York Univ.

Elected to Associate Member Grade

Anslyn, Samuel Stephen, Jr., Publication Mgr. & Editor of Company Newspaper, Marquardt Aircraft Co.

Cooper, Everett A., V.-P. & Gen. Mgr., Globe Corp.

Fournier, J. P., Inspector, Civil Aviation, Dept. of Transport, Air Services (Montreal).

Jessup, Richard O., Owner, Jessup Engineering Co.

Kambrich, Earl R., Asst. Gen. Mgr., Aero Engineering, Inc.

Lichty, Dale A., V.-P. & Gen. Sales Mgr., Hydro-Aire, Inc.

Ross, William M. Jr., Industrial Engr., Texas Engineering & Manufacturing Co.

Schmitt, Albert O., B.S.M.E., Field Engrg., Aero Engineering, Inc.

Smith, Donald J., Sq. Comdr., Illinois Air National Guard.

Sullivan, Thomas J., A.B., Mgr. of Contracts, Consolidated Vultee Aircraft Corp. (Ft. Worth).

Transferred to Associate Member Grade

Luther, Kenneth R., Chief Design Engr. & Contract Administrator, Babcock Radio Engineering, Inc.

Elected to Technical Member Grade

Brown, Donald B., Jr., S.B.Ae.E., Struct. Engr., Bell Aircraft Corp.

Heller, Alfred, Dipl. Ing., ETH, Asst. to Prof. Rauscher, Aircraft Struct. & Aeroelasticity, Swiss Federal Institute of Technology (Zurich).

Law, William, B.Sc., Chief Design Engr., Spartan Air Services, Ltd. (Ottawa).

McCarty, John E., B.S. in Ae.E., Assoc. Engr., Douglas Aircraft Co., Inc. (Santa Monica).

Ness, Andrew K., M.E., Flight Test Engr., Naval Air Test Center (Patuxent River).

Pratt, William H., B.M.E., Proj. Engr., Marine Aircraft Corp.

Silveira, Milton A., B.S. in M.E., Chief, Engrg. Br., U.S. Army Transportation Corps, Army Aircraft Field Service Office (St. Louis).

Sladkus, John G., Diploma (D.L.C. Eng.), Jr. Design Draftsman, Air Research Assoc.

Stratford, H. Ralph, Devel. Engr., Dowty Equipment of Canada, Ltd.

Titus, Charles K., M.S.E.E., Engr., Air Arm Div., Westinghouse Electric Corp.

Transferred to Technical Member Grade

Bassett, Kimbrough S., B.S., 2nd Lt., USAF; Student Pilot, Hondo AFB.

Beatty, John W., B. of Ae.E., Lt. & Pilot, USN.

Becker, William C., Jr., B.S. (Aero.), Engr. "C," Airplane Engrg. Div., McDonnell Aircraft Corp.

Boutelle, A., M.S., Asst. Chief Engr., U.S. Rubber International.

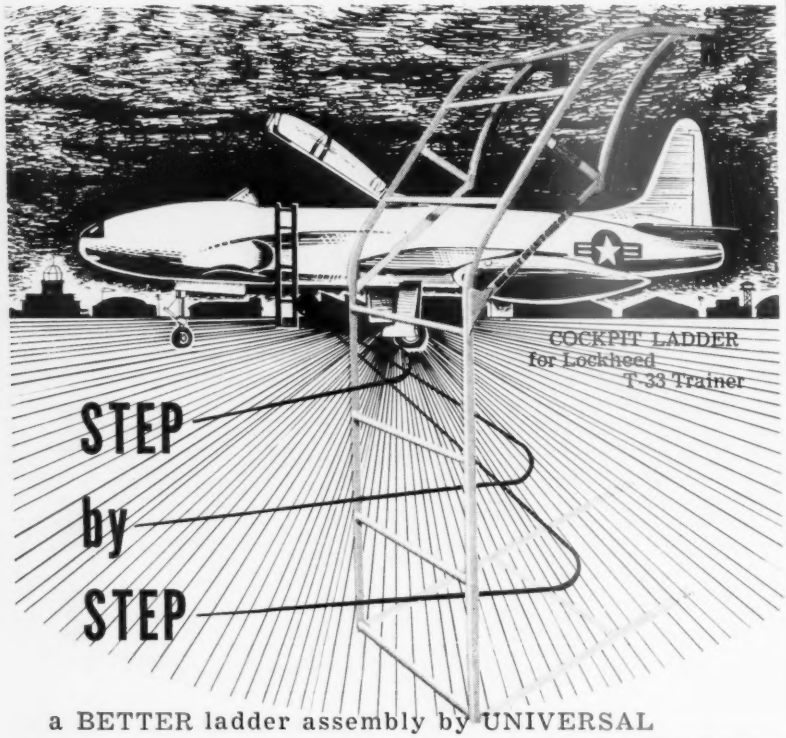
Christianer, Melvin L., B.S., (Aero.), Static Test Engr., Beech Aircraft Corp.

Corsette, Douglas F., M.S., Mech. Eng., Research & Devel. Labs., Hughes Aircraft Co., Inc.

Curry, John M., Engrg. Draftsman "B," North American Aviation, Inc. (Los Angeles).

Davidson, Don E., Jr. Eng. "B," Design Group, Boeing Airplane Co. (Seattle).

Dishlevoy, Roy W., Draftsman, Canadair, Ltd.



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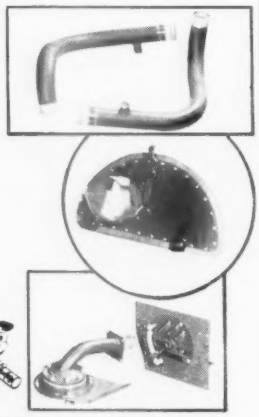

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Francis, Henry L., B.S. in Ae.E., Aerodynamics Engr., Chance Vought Aircraft Div., United Aircraft Corp.

Frazier, Robert H., Jr., B.S. in Ae.E., Engr.—Install., Pratt & Whitney Aircraft Div., United Aircraft Corp.

Frier, John M., Jr., B.S., Ens., USN.

Genetti, Bernard K., M.S. in Ae.E., Aerodynamicist, Aircraft Gas Turbine Div., General Electric Co.

Gould, Harlan B., Research Analyst, North American Aviation, Inc. (Los Angeles).

Greenquist, Sven P., Jr., Jr. Engr.—Aircraft Design, Consolidated Vultee Aircraft Corp. (San Diego).

Grommesh, Donald Joseph, B.S.M.E. (Aero.).

Hewitt, Robert P., Jr., B.S. in Ae.E., Stress Analyst "C," North American Aviation, Inc. (Columbus).

Kelbert, George O., M.S. in Ae.E., Field Engr.-Tech. Rep. to the Air Force, Consolidated Vultee Aircraft Corp. (Ft. Worth).

Kondall, Albert R., B. of Ae.E., Capt., USAF; Chief, Components Br., Production Control, Hq., AMC, Wright-Patterson AFB.

Martin, Willis O., B. of Ae.E., Jr. Engr., Performance Sect., Aerodynamics Group, Consolidated Vultee Aircraft Corp. (Ft. Worth).

McMillin, Glen R., B.S., Jr. Research & Devel. Engr., Goodyear Aircraft Corp.

Parry, Thomas C., Jr., Devel. Engr., Physical Testing Dept., Goodyear Aircraft Corp.

Plemel, James E., B.S. in Ae.E., Assoc. Engr., Douglas Aircraft Co., Inc. (El Segundo).

Porter, Samuel R., B.S. in Ae.E., 2nd Lt., USAF; Pilot Training, San Marcos AFB.

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Soule, Peter W., B.S. in Ae.E., 2nd Lt., USAF; Airborne Electronics Officer, Alaskan Air Command.

Talnack, John J., Liaison Engr., Douglas Aircraft Co., Inc. (El Segundo).

Wallis, John R., Jr., S.B. in Ae.E., 2nd Lt., USAF; Flight Test Proj. Engr., Edwards AFB.

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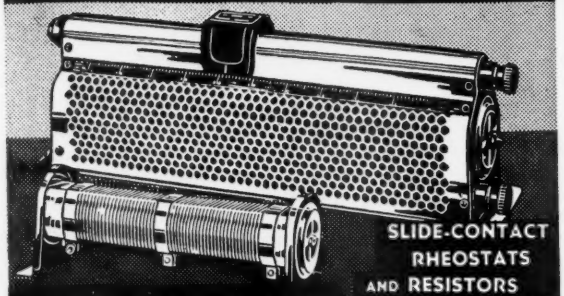

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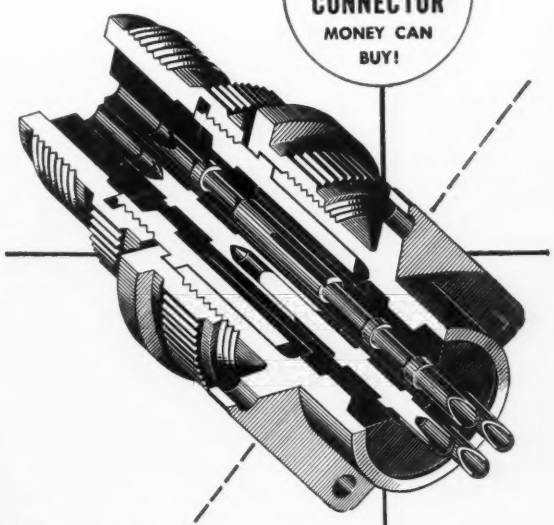

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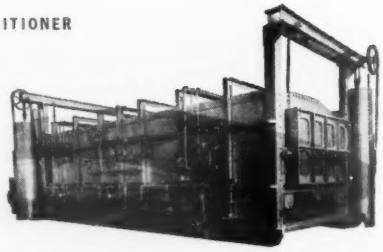

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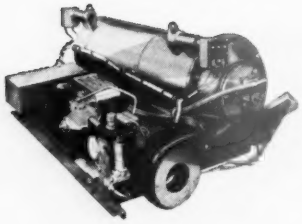

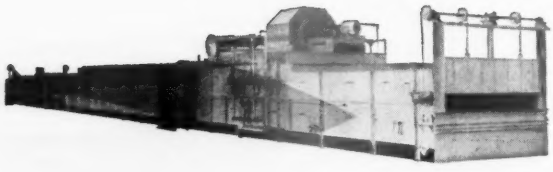

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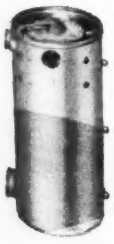

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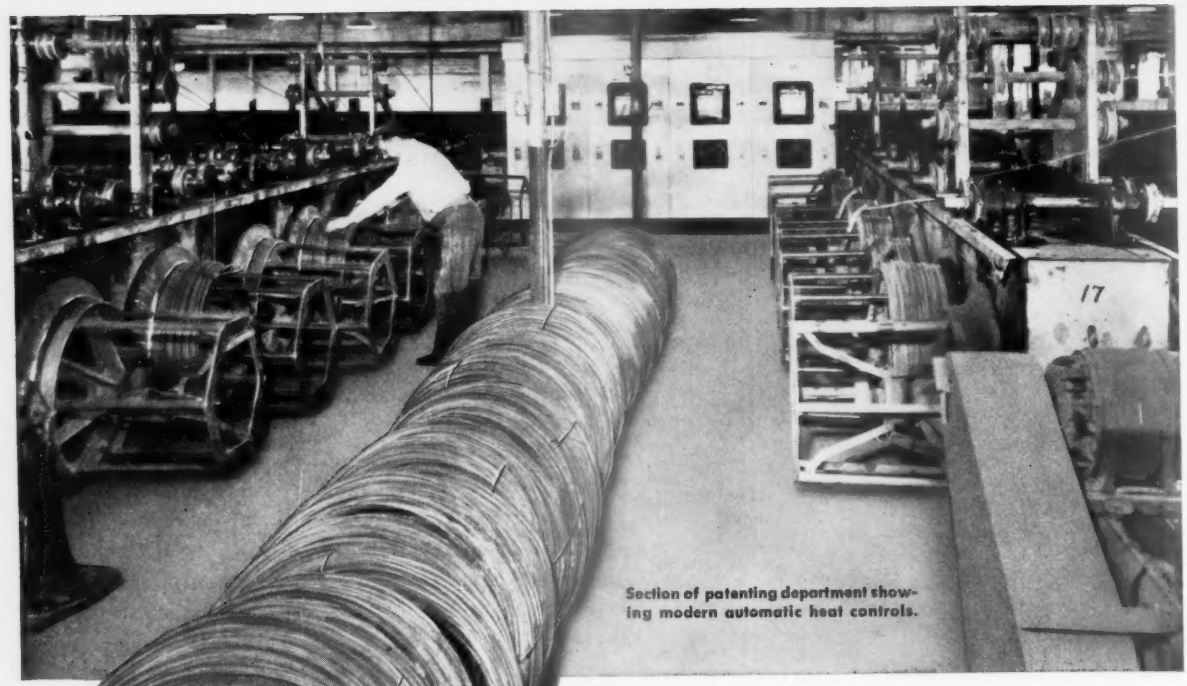

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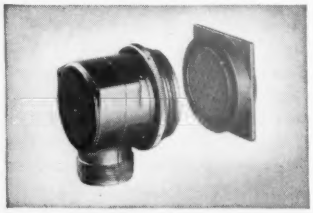

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Aerodynamics

What is This Thing Called Mach 1? D. L. Ellis. *The Aeroplane*, Apr. 3, 1953, p. 434. Discussion of transonic and supersonic speeds.

Boundary Layer & Thermoaerodynamics

Deflection and Diffusion of a Light Ray Passing Through a Boundary Layer. H. W. Liepmann. *Douglas Rep. SM-14397*, May 16, 1952. 13 pp.

On the Fundamentals of the Boundary Layer Theory. M. Z. Krzywoblocki. *J. Franklin Inst.*, Apr., 1953, p. 289. 43 refs.

The Determination of Local Forced-Convection Coefficients for Spheres. John R. Cary. *Trans. ASME*, May, 1953, p. 483.

Influence of Unheated Starting Sections on the Heat Transfer from a Cylinder to Gas Streams Parallel to the Axis. William Tessin and Max Jakob. *Trans. ASME*, May, 1953, p. 473.

An Investigation of Heat Transfer From an Inclined Flat Plate in Free Convection. B. R. Rich. *Trans. ASME*, May, 1953, p. 489.

Calcul de la Couche Limite Compressible; Applications Pratiques Élémentaires des Méthodes Oswatitsch-Walz et Grushwitz-Walz. Adalbert Ouidart. *France, Min. de l'Air PST 258*, 1952. 66 pp. In French. Calculation of the compressible boundary layer.

Some Aspects of Laminar Boundary Layer Separation in Compressible Flow with no Heat Transfer to the Wall. G. E. Gadd. *Aero. Quart.*, Feb., 1953, p. 123.

Grenzschichten an Zylindrischen Körpern mit Nichtstationärer Querbewegung. Walter Wuest. *ZAMM*, June, 1952, p. 172. In German. Three-dimensional nonstationary problems of laminar boundary-layer currents in flow against cylindric bodies with axial movement dependent on time.

The Laminar Boundary Layer of a Rotating Body of Revolution. C. R. Illingworth. *Philos. Mag.* (*7th Ser.*), Apr., 1953, p. 389.

Control Surfaces

A Note on the Problem of Aileron Reversal at Transonic Speeds. B. A. Hunn. *J. RAeS.*, Apr., 1953, p. 237.

Fluid Mechanics & Aerodynamic Theory

Actes du Colloque International de Mécanique, Poitiers, 1950. II, III—Étude sur la Mécanique des Fluides. *France, Min. de l'Air PST* 250, 251, 1951. 294; 335 pp. 368 refs. In French. Experimental flow studies; aerodynamics and ballistics; subsonic, transonic, and supersonic flow; turbulence and other factors.

Analysis of Heat Transfer and Fluid Friction for Fully Developed Turbulent Flow of Supercritical Water with Variable Fluid Properties in a Smooth Tube. Robert G. Deissler and Maynard F. Taylor *U.S., NACA RM E53B17*, Apr. 9, 1953. 29 pp.

Chronophotographie des Vibrations d'un Fluide. Joseph-Maurice Bourot. *France, Min. de l'Air PST 264,* 1952. 79 pp. In French.

Contribution à l'Étude du Coefficient de Viscosité des Liquides. Jacques Huetz. *France, Min. de l'Air PST 260,* 1952. 70 pp. In French. Experimental studies on the measurement of the coefficient of the viscosity of liquids.

Contribution à l'Étude Expérimentale des Écoulements Gazeux Rapides par les Méthodes de Perturbation Utilisation des Ultrasons (Contribution to the Experimental Study of Swift Gaseous Flows by Perturbation Methods Utilizing Ultrasonics). Genevieve Dubois. *France, Min. de l'Air PST 269,* 1952. 57 pp. In French.

Flow of Gases Through Plastic Membranes. David William Brubaker and Karl Kammermeyer. *Ind. & Eng. Chem.,* May, 1953, p. 1148.

Fluid Dynamics. Thomas Baron and A. K. Oppenheim. *Ind. & Eng. Chem.,* May, 1953, p. 941. 289 refs. Major trends in flow research; review of the literature.

Hodograph Methods in Gas Dynamics. D. C. Pack. *U. Md. Inst. Fluid Dynamics & Appl. Math., Lecture Ser. 17,* 1951–52. 59 pp.

Molecular Transport Properties of Fluids. E. F. Johnson. *Ind. & Eng. Chem.,* May, 1953, p. 902. 126 refs. Review of the literature.

Sur l'Identité d'un Problème de Frontière Libre en Elasticité avec un Problème d'Écoulement (On the Identity of a Free Boundary Problem in Elasticity Combined with a Flow Problem). Cahit Arf. *Istanbul Tech. U. Bul.,* No. 1, 1951, p. 1.

A Note on the Theory of the Constant-Area Mixing of Compressible Flows as Applied to High-Speed Wind Tunnel Design. F. G. Irving. *Aero. Quart.,* Feb., 1953, p. 164.

Operatorenmethoden in der Gasdynamik. Stefan Bergman. *ZAMM,* Feb.-Mar., 1952, p. 33. In German. In irrotational compressible subsonic flow problems, the use of integral operations to transform the class of analytic functions of a complex variable into the class of the stream functions representing subsonic flows of ideal gases around profiles of arbitrary shapes.

Theory of Compressible Fluids. H. Luskin. *Douglas Rep. SM-13560,* April 8, 1944. 116 pp. Based on lectures by F. H. Clauser.

The Two-Dimensional Irrotational Flow of a Compressible Fluid Around a Corner. H. J. Davies. *Quart. J. Mech. & Appl. Math.,* Mar., 1953, p. 71.

On Unsteady Flow of Compressible Viscous Fluids. G. Ludford, H. Polachek, and R. J. Seeger. *J. Appl. Phys.,* Apr., 1953, p. 490.

Calculation of External Airplane Drag from Measured Rocket Model Decelerations. Harold Klein. *Douglas Rep. SM-13704,* Nov. 22, 1949. 14 pp.

Conical Flow Without Axial Symmetry. Antonio Ferri. *L'Aerotecnica,* Feb. 15, 1953, p. 69.

The Couple on a Rotating Spheroid in a Slow Stream. L. Sowerby. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 327.

Écoulement Transsonique Autour d'Ailes à Forte Flèche (Transonic Flow About Wings of Extreme Sweep). Robert Legendre, E. A. Eichelbrenner, and A. v. Baranoff. *France, ONERA Pub. 53,* 1952. 54 pp. In French.

The Flow of Fluid Along Corners and Edges. L. Sowerby and J. C. Cooke. *Quart. J. Mech. & Appl. Math.,* Mar., 1953, p. 50.

An Investigation of the Flow About Cones and Wedges at and Beyond the Critical Angle. G. W. Johnston. *J. Aero Sci.,* June, 1953, p. 378. Results of studies at the University of Toronto, Institute of Aerophysics.

Note on Hydrodynamics. Charles Darwin. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 342. Theoretical solution for the problem of a solid body moving uniformly through an infinite incompressible fluid.

Über die Entstehung von Ringwellen an einer Flüssigkeits-Oberfläche Durch unter Dieser Gelegene, Kugelige Periodische Quellensysteme. Hsien Chih Liu. *ZAMM,* July, 1952, p. 211. In German. Investigation of a spherical source acting periodically as the center of perturbation, with gravity as the only external force, below the surface of an ideal liquid with infinitely extended free surface and infinite depth; computation of the resulting displacement of the surface from the velocity potential of the source when the time coordinate is indefinitely increased.

Virtual Momentum and Slender Body Theory. John W. Miles. *Douglas Rep. SM-14652,* Jan. 15, 1953. 9 pp.

A Weak Spherical Source in a Rotating Fluid. K. Stewartson. *Quart. J. Mech. & Appl. Math.,* Mar., 1953, p. 45.

On the Two-dimensional Laminar Boundary Layer Equations for Hypersonic Flow in Continuum & in Rarefied Gases. M. Z. Krzywoblocki. *J. Aero. Soc. India,* Feb., 1953, p. 1.

Sur la Résistance Pure en Fluide Compressible et Parfait (On the Pure Drag in an Incompressible and Perfect Fluid). Maurice Roy. *L'Aerotecnica,* Feb. 15, 1953, p. 110. In French.

Historique de l'Aérodynamique Supersonique (History of Supersonic Aerodynamics). Jean Brocard. *Tech. et Sci. Aéronautiques,* No. 2, 1952, p. 96. In French.

A Study of Second-Order Supersonic Flow Theory. Milton D. Van Dyke. (*U.S., NACA TN 2200,* 1951.) *U.S., NACA Rep. 1081,* 1952. 23 pp. 42 refs.

Velocity Distribution on a Family of Thin Conical Bodies with Zero Incidence According to Linearized Supersonic Flow Theory. Fritz Hjelte. *Stockholm, Kungliga Tekniska Högskolan, Inst. för Flygteknik, KTH-Aero TN 22,* June 4, 1952. 16 pp.

On the Non-existence of Limiting Lines in Transonic Flows. C. S. Morawetz and I. I. Kolodner. *Commun. on Pure & Appl. Math.,* Feb., 1953, p. 97.

Two-Dimensional Flow Equations in the Transonic Region. Ernest W. Graham. *Douglas Rep. SM-13056,* Oct. 5, 1948. 10 pp.

Internal Flow

Flow Changes in Gases in which Mass and Impulse are Conserved. L. G. Dawson. *Aero. Quart.,* Feb., 1953, p. 193. Study of the state of a gas flowing in a duct of constant area.

On the Flow Between Two Rotating Coaxial Disks. K. Stewartson. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 333.

Die Strömung an einer Angeblasenen Rotierenden Scheibe. H. Schlichting and E. Truckenbrodt. *ZAMM,* Apr.–May, 1952, p. 97. In German. Computation of the laminar flow about a rotating plane disc with the fluid flowing against the disc in axial direction.

Die Wirkung von Geraden Strömungsgittern aus Ebenen Platten (The Directing Effect of a Flat Plate Cascade). Albert Betz. *L'Aerotecnica,* Feb. 15, 1953, p. 10. In German.

Effects of Inertia on Flow of Stream Through Nozzles and Blading of Axial-Flow Turbines. W. J. Kearton. *IME Proc. (A),* No. 4, 1952, p. 429; Communications, p. 437.

The Elimination of Wall Effects in Axial-Flow Compressor Stages. J. M. Stephenson. *J. RAeS.,* Apr., 1953, p. 241.

Discussion of Boundary-Layer Characteristics Near the Wall of an Axial-Flow Compressor. Artur Mager, John J. Mahoney, and Ray E. Budinger. (*U.S., NACA RM E51H07,* 1951.) *U.S., NACA Rep. 1085,* 1952. 20 pp.

Étude Générale de l'Écoulement d'un Gaz à Travers une Tuyère Quelconque et du Passage par la Vitesse du Son (En Régime Permanent ou Quelconque avec Apport de Chaleur et Réaction Chimique Eventuels). Max Serruys. *France, Min. de l'Air PST 272,* 1952. 62 pp. In French. Study of the flow of a gas through a pipe at sonic speeds, with heat addition.

A Note on the Performance of Ducted Fans. Bryan Thwaites. *Aero. Quart.,* Feb., 1953, p. 179.

On the Resistance of Screens. K. E. G. Wieghardt. *Aero. Quart.,* Feb., 1953, p. 186.

La Resistenza di un Tubo Quasi Cilindrico in Corrente Supersonica (On the Drag of a Quasi-Cylindrical Tube in Supersonic Stream). Enrico Pistolesi. *L'Aerotecnica,* Feb. 15, 1953, p. 100. In Italian.

Die Verteilung der Durchflussmenge in einem ebenen Verzweigungssystem. H. Reichardt and W. Tollmien. *Mitteil. Max-Planck-Inst. für Strömungsforschung,* No. 7, 1952. 48 pp. In German. Experimental study of the distribution flow volume in a plane branched system.

Analysis of Heat Addition in a Convergent-Divergent Nozzle. Donald P. Hearth and Eugene Perchonok. *U.S., NACA TN 2938,* Apr., 1953. 18 pp.

Supercritical Gaseous Discharge With High Frequency Oscillations. Luigi Crocco. *L'Aerotecnica,* Feb. 15, 1953, p. 46.

Two Methods for Calculation of Intake Air Vibration. I. Hakki Öz. *Istanbul Tech. U. Bul.,* No. 1, 1951, p. 90.

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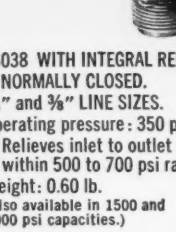

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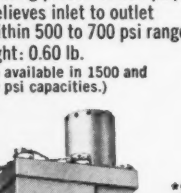

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Performance

Langley Full-Scale-Tunnel Tests of the Custer Channel Wing Airplane. Jerome Pasamanick. *U.S., NACA RM L53A09*, Apr. 7, 1953. 57 pp. Determination of lift and some stability and control characteristics.

Study of Motion of Model of Personal-Owner or Liaison Airplane Through the Stall and into the Incipient Spin by Means of a Free-Flight Testing Technique. Ralph W. Stone, Jr., William G. Garner, and Lawrence J. Gale. *U.S., NACA TN 2923*, Apr., 1953. 28 pp.

Stability & Control

The Effect of Non-Linear Aerodynamic Characteristics on the Dynamic Response to a Sudden Change in Angle of Attack. Telford W. Oswald. *Douglas Rep. SM-14140*, June 27, 1951. 57 pp.

Sidewash and Controllability. H. K. Millicer. *Aircraft* (Australia), Mar., 1953, p. 26.

Wings & Airfoils

The Application of Relaxation Methods to the Solution of Differential Equations in Three Dimensions. II—Potential Flow Round Aerofoils. D. N. de G. Allen and S. C. R. Dennis. *Quart. J. Mech. & Appl. Math.*, Mar., 1953, p. 81.

Contribution à l'Étude Aérodynamique de l'Aile et de l'Hélice. Maurice Ménard. *France, Min. de l'Air PST 262*, 1952. 187 pp. In French. Experimental studies on the aerodynamic characteristics of wings and propeller blades.

Détermination des Charges Aérodynamiques Agissant sur l'Empennage Horizontal pour les Calculs de Résistance des Matériaux (Determination of the Active Aerodynamic Forces on the Horizontal Tail Plane in Order to Calculate the Strength of Materials). W. Just. *Tech. et Sci. Aéronautiques*, No. 4, 1952, p. 242. In French.

Détermination en Soufferie de la Distribution de la Circulation le Long de l'Envergure des Ailes par la Méthode des Fumées; Application à l'Étude des Ailes non Classiques (en Flèche). J. Valensi, H. Parigi, et M. Rebont. *France, Min. de l'Air PST 255*, 1951. 37 pp. In French. Wind-tunnel calculation of the distribution of circulation along the wing by the smoke-stream method; application to the study of nonclassical wings (swept-back).

Eine neue Methods zur Berechnung der Strömungsfunktionen bei Zeitlich Veränderlicher Kontur. Guntram v. Gorup. *ZAMM*, Nov.–Dec., 1952, p. 371. In German. Flow stream functions for the exterior of a contour variable with time and determined in a closed form, assuming the mapping function to be meromorphic; applications.

The Flow over Symmetrical Aerofoils Without Incidence at Sonic Speed. Tore R. Gullstrand. *Stockholm, Kungliga Tekniska Högskolan, Inst. för Flygteknik, KTH-Aero TN 24*, Mar., 1952. 39 pp.

The Flow over Two-Dimensional Aerofoils at Incidence in the Transonic Speed Range. Tore R. Gullstrand. *Stockholm, Kungliga Tekniska Högskolan, Inst. för*

Flygteknik, KTH-Aero TN 27, Oct. 7, 1952. 25 pp.

Low Aspect Ratio Wings with Small Thickness at Zero Lift in Subsonic and Supersonic Flow. Friedrich Keune. *Stockholm, Kungliga Tekniska Högskolan, Inst. för Flygteknik, KTH-Aero TN 21*, June 15, 1952. 57 pp.

Peso Teorico e Peso Reale delle Ali a Sbalzo (Theoretical Weight and Actual Weight of Cantilever Wings). Giuseppe Gabrielli. *L'Aerotecnica*, Feb. 15, 1953, p. 72. In Italian.

Quelques Propriétés Aérodynamiques des Ailes de Faible Allongement (Some Aerodynamic Properties of Wings of Slight Aspect Ratio). P. Bevierre. *Tech. et Sci. Aérodynamiques*, No. 2, 1952, p. 106. In French.

Theoretical Calculation of the Downwash Factor for Unswept Trapezoidal Wings with Regard to the Compressibility for Subsonic Velocities. W. Jacobs. *Sweden, Flygtekniska Försöksanstalten, FFA Meddelande NR 38*, 1950. 20 pp.

Theoretical Damping in Roll and Rolling Moment Due to Differential Wing Incidence for Slender Cruciform Wings and Wing-Body Combinations. Gaynor J. Adams and Duane W. Dugan. *U.S., NACA Rep. 1088*, 1952. 11 pp. Extends the analysis reported in *NACA TN 2270*, 1951.

A Theoretical Discussion of Some Properties of Transonic Flow over Two-Dimensional Symmetrical Aerofoils at Zero Lift with a Simple Method to Estimate the Flow Properties. Tore R. Gullstrand. *Stockholm, Kungliga Tekniska Högskolan, Inst. för Flygteknik, KTH-Aero TN 25*, June 25, 1952. 20 pp.

Untersuchungen an einem Symmetrischen Tragflügel mit Spaltlos Angeschlossenem Ruder bei Raschen Aenderungen des Ruderausschlags (ebene Strömung.) H. Drescher. *Mitteil. Max-Planck-Inst. für Strömungsforschung*, No. 6, 1952. 71 pp. In German. Investigations of a symmetrical airfoil with attached control surfaces and with rapid variation of control-surface-deflection plane flow.

The Upwash Correction for an Oscillating Wing in a Wind Tunnel. Theodore R. Goodman. *J. Aero. Sci.*, June, 1953, p. 383.

Wind Tunnel Investigations on Rotating Blades of Aerofoil Section. K. H. Khalil. *IME Proc. (A)*, No. 4, 1952, p. 419; **Communications,** p. 426.

Aperçu sur la Trainée des Ailes aux Vitesses Supersoniques (Estimate on the Drag of Wings at Supersonic Speeds). J. Germain. *Tech. et Sci. Aéronautiques*, No. 2, 1952, p. 100. In French.

Drag Due to Lift at Supersonic Speeds of a Delta Wing-Tail Combination. M. E. Graham. *Douglas Rep. SM-13601*, Sept., 1949. 14 pp.

The Indicial Lift for Two-Dimensional Incompressible Wing Theory. E. V. Laitone and R. Sedney. *Douglas Rep. SM-14225*, Dec. 6, 1951. 20 pp.

Lift Developed on Unrestrained Rectangular Wings Entering Gusts at Subsonic and Supersonic Speeds. Harvard Lomax. *U.S., NACA TN 2925*, Apr., 1953. 44 pp.

Sul Calcolo della Resistenza di Spessore delle Ali Rettangolari a Velocità Supersonica (On the Calculation of the Thickness Drag of Supersonic Rectangular Wings). Antonio Eula. *L'Aerotecnica*, Feb. 15, 1953, p. 54. In Italian.

Sur Quelques Problèmes Aérodynamiques des Ailes Supersoniques; L'Hypersustentation des Ailes en Flèche et des Ailes Delta (On Some Aerodynamic Problems of Supersonic Wings; Increase of Lift of Swept Wings and Delta Wings). J. Lacaine. *Tech. et Sci. Aéronautiques*, No. 2, 1952, p. 120. In French. Includes charts and diagrams.

Calcolo della Velocità Indotta da un'Ala in Corrente Supersonica Linearizzata (On the Calculation of the Velocity Induced by Wing in Linearised Supersonic Flow). Carlo Ferrari. *L'Aerotecnica*, Feb. 15, 1953, p. 65. In Italian.

Supersonic Wing Profile Analysis. E. Rutowski and A. Silvester. *Douglas Rep. SM-13097*, Sept. 23, 1947. 22 pp.

Thin Airfoil Theory at High Mach Numbers. Francis H. Clauser. *Douglas Rep. SM-4912*, Jan. 19, 1944. 20 pp.

Deflection of Delta Wings Having a Carry-Through-Bay Chord Smaller than the Wing Root Chord. Roger W. Peters and Manuel Stein. *U.S., NACA TN 2927*, May, 1953. 25 pp.

The Generalization of Prandtl's Equation for Yawed and Swept Wings. A. I. van de Vooren. *Netherlands, NLL Rep. F. 121*, Dec. 23, 1952. 24 pp.

Influence Functions for Computing Lift and Rolling Moment of a Twisted Narrow Delta Wing. Beverly Beane. *Douglas Rep. SM-14532*, Oct., 1952. 8 pp.

The Lifting Trapezoidal Wing with Small Aspect Ratio at Supersonic Speed. Herman Behrbohm. *SAAB TN 10*, Apr. 15, 1952. 37 pp.

A Note on the Estimation of Some Low Speed Characteristics of Delta Wings. R. G. Rose. *Coll. of Aeronautics, Cranfield, Rep. 68*, Jan., 1953. 25 pp. 24 refs.

Aeroelasticity

Le Calcul de Flutter en Régime Supersonique (Calculation of Flutter in Supersonic Operation). Werner Ruppel and Robert Weber. *ZAMP*, Mar. 3, 1953, p. 128. In French.

Sul Calcolo delle Velocità Critiche delle Ali (A Method of Analysis for Flutter and Divergence of Wings). Luigi Broglio. *L'Aerotecnica*, Feb 15, 1953, p. 13. In Italian.

Numerical Analysis of Damped Vibrating Systems. E. Stanley Ault and William J. Graff, Jr. *Mach. Des.*, May, 1953, p. 169.

Plastic Models for Vibration Analysis. G. O. Sankey. *Mach. Des.*, May, 1953, p. 125.

Aeronautics, General

The Next Half Century. C. C. Furnas. *Aero. Eng. Rev.*, June, 1953, p. 24. Prediction on fuels, propulsion plants, speed, helicopters, safety and reliability of service, volume of traffic, space travel.

Air Transportation

Air Transport Trends. Otto E. Kirchner, Moderator. *Skyways*, June, 1953, p. 20. Flight Operations Round Table discussion.

Civil Jet Operations; B.O.A.C.'s Comet Experience. A. M. A. Majendie. *Flight*, May 1, 1953, p. 556. (Also in *The Aeroplane*, May 1, 1953, p. 583.)

Jet Transport Operationally Speaking. Edward C. Wells. *Boeing Mag.*, Apr., 1953, p. 6.

Metodo Rapido di Valutazione delle Qualità Economiche dei Velivoli da Trasporto (A Quick Method for the Evaluation of Economic Performance of Transport Aircraft). Alfred Crocco. *L'Aerotecnica*, Feb. 15, 1953, p. 40. In Italian.

Progressive Overhaul. Fred A. Page. *Douglas Serv.*, Mar.-Apr., 1953, p. 14. Maintenance requirements and operations at United Air Lines.

Some Notes on Weighing and Loading Transport Aircraft. R. A. Fry. *J. SLAE*, Mar., 1953, p. 3.

Technical Problems of Integrating a Three Company Airline. Olof W. Carlstein. *Douglas Serv.*, Mar.-Apr., 1953, p. 2. Engineering, maintenance, and other problems of Scandinavian Airlines System (SAS).

The Turbine Engine and Air Transportation. C. R. Smith. *Syracuse U. Transp. Conf. Paper*, Apr. 29, 1953. 18 pp. General jet characteristics, selection of power plants and airplane types, fuel consumption, speed, economics, and other factors.

Airplane Design

Comet Engineering; The Performance of Airframe, Engines and Equipment in Operational Service. *Flight*, May 1, 1953, p. 551, cutaway drawings.

Current Safety Considerations in the Design of Passenger Seats for Transport Aircraft. Hugh De Haven. *Cornell U. Med. Coll. Crash Injury Res. Paper*, June, 1952. 12 pp.

The Design and Installation of Aircraft Sanitary Systems. G. S. Bowey. *Aircraft Eng.*, Apr., 1953, p. 101.

Design of the de Havilland Otter. F. H. Buller and R. D. Hiscocks. (*Paper, Eng. Inst. Canada*, 1953). *de Havilland Gazette*, Apr., 1953, p. 66.

The Double-Deck Provence; 107-Seat Breguet Introduced by Air France on N. African Routes. John Stroud. *Flight*, Apr. 10, 1953, p. 458.

Evolution and Revolution; the Vickers Viscount. Oliver Stewart. *Can. Av.*, Apr., 1953, p. 36, cutaway drawing.

Evolution of the F-86 Sabre Jet Fighter. Ray Rice. *Auto. Ind.*, Apr. 15, 1953, p. 45, cutaway drawing.

First Report of the ALPA Performance Committee. William W. Moss, James P. Talton, and Jack A. Durham. *ALPA Paper*, March 12, 1953. 20 pp. Maximum and minimum performance limits for transport type aircraft.

Jet Transport. ALPA Eng. & Air Safety Dept. *Air Line Pilot*, Apr., 1953, p. 2. Recommendations for building a jet transport based on a study of operating problems.

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The Latest Vampire Trainer. *Flight*, May, 1953, p. 578, cutaway drawing.

Lighter Fighters? D. M. Desoutter. *Aeronautics*, Apr., 1953, p. 28. Design and development review.

The R.Ae.C. Aeroplane Designs Competition; Racers for the Future? *The Aeroplane*, Apr. 10, 1953, p. 457. (Also in *Flight*, Apr. 10, 17, 1953, pp. 451; 491.) Structural drawings and engineering specifications.

Some Aspects of High Performance Jet Aircraft. W. A. Waterton. (Lecture, RAeS, Mar. 12, 1953.) *The Engr.*, Apr. 3, 1953, p. 507. Abridged.

The Story of the Viscount. *The Aeroplane*, Mar. 27, 1953, p. 369. Partial contents: The Designer's Approach, G. R. Edwards. The Air Line Operator's Part, Peter G. Masefield. Power Plant and Ancillary Gear. Rolls-Royce Dart (colored cutaway drawing). Progress in Performance, H. A. Taylor. Transport Pilot's Viewpoint, R. E. Gillman. (Also see *Flight*, Mar. 20, 1953.)

Temperature Gradients and Heat Stresses in Brake Drums. G. A. G. Fazekas. *SAE Summer Meeting, Atlantic City, N.J., June 1–6, 1952, Preprint T16*, 55 pp. 25 refs.

Turbine-Powered Aircraft Design Specifications Desired by Operators and Their Implications for Airport Design. Milton W. Arnold. *Airport Operators Council, Paper*, Mar. 24, 1953. 12 pp.

Turbine Powered Transport Airplane; Design and Operating Recommendations. Theo. G. Linnert and Carl F. Eck. *ALPA Eng. & Air Safety Dept. Paper*, Dec. 9, 1952. 38 pp.

Viscount and Dart; Putting the First Turboprop Airliners to Work. David West. *Aeronautics*, May, 1953, p. 40. Design, performance, and comparative operating costs data.

Airports

L'Adaptation de l'Infrastructure et des Aides à l'Approche aux Aeronefs à Voilure Tournante (Adaptation of the Ground Organization and of Approach Aids to Rotary-Wing Aircraft). Raymond Peladan. *Tech. et Sci. Aéronautiques*, No. 1, 1952, p. 48. In French.

Modifications and Tests of Radioactive Probes for Measuring Soil Moisture and Density. Paul F. Carlton, D. J. Belcher, T. R. Cuykendall, and H. S. Sack. *U.S., CAA TDR 194*, Mar., 1953. 13 pp.

Turbine-Powered Aircraft Design Specifications Desired by Operators and Their Implications for Airport Design. Milton W. Arnold. *Airport Operators Council, Paper*, Mar. 24, 1953. 12 pp.

Aviation Medicine

Clinical Research on the Subject of a Test on Aviator's Fatigue. R. Monjauze, F. Plas, G. and J. Verdeaux, J. Bourdinaud, A. Missenard, and R. Le-Febvre. *J. Av. Med.*, Apr., 1953, p. 143.

Correlation of Static and Physical Endurance. I—A Test of Physical Performance Based on the Cardiovascular and Respiratory Response to Gradually In-

creased Work. Bruno Balke. *USAF SAM Project 21-32-004 Rep. 1*, Apr., 1952. 14 pp.

Effects of a Military Program upon Physical Performance. J. Gordon Wells and Thaddeus J. Domanski. *USAF SAM Project Rep. 21-32-029*, May, 1952. 6 pp.

The Evaluation of Clinical Tests for Atherosclerosis; The Role of Adenosine-5-Monophosphate in Cholesterol Metabolism. William W. Calhoun, Lawrence J. Milch, Robert F. Redmond, and others. *USAF SAM Project 21-1601-0007 Rep. 1*, Jan., 1953. 3 pp.

Psychiatric Screening of Flying Personnel. IV—An Experimental Investigation of Development of an EEG Index of Anxiety Tolerance by Means of Photic Stimulation—Its Validation by Psychological and Psychiatric Criteria. George A. Ulett, Goldine Gleser, Ann Lawler, and George Winokur. *USAF SAM Project 21-37-002 Rep. 4*, Aug., 1952. 39 pp. 38 refs.

Reports of Research in the Field of Engineering Psychology. Julien M. Christensen and Harry R. Collins. *USAF TR 53-75*, Apr. 1, 1953. 25 pp. 198 refs. A bibliography of functional groupings of reports published by the WADC Psychology Branch, Aero Medical Lab., Directorate of Research, since its inception in 1945.

Spectacles in Jet Flying. Paul H. Evans, and Jack W. Peachy. *J. Av. Med.*, Apr., 1953, p. 138.

A Twelve Year Follow-up Study of 1056 U.S. Naval Flyers. Ashton Graybiel, John M. Packard, and John S. Graettinger. *Mil. Surgeon*, May, 1953, p. 328. Follow-up of the "Pensacola Study" of physiological and psychological factors in aeromedicine.

Effects of Acceleration Upon the Cerebral Metabolism and Cerebral Blood Flow; Phase II—Studies on Cerebral Physiology of Monkeys at 12 Negative G. T. D. Duane, R. L. Wechsler, J. E. Ziegler, and E. L. Beckman. *U.S., NADC Rep. NADC-MA-5204*, May 21, 1952, 51 pp. Aviation Medical Acceleration Lab., Johnsville, Pa., research.

Die Psychophysiologie der Beschleunigungswirkung. Siegfried J. Gerathewohl. *Weltraumfahrt*, Jan., 1953, p. 15. The psychophysiology of the mechanism of acceleration.

A Study of Fluid Shifts in Small Rodents Exposed to Accelerative Stress. Charles F. Gell and D. Cranmore. *U.S., NADC Rep. NADC-MA-5201*, Apr. 7, 1952. 49 pp. Aviation Medical Acceleration Lab., Johnsville, Pa., studies.

The Effect of Moderate Altitude Upon Human Gastric Emptying Time. Everett Shocket, Margaret M. Jackson, and Harry C. Dyme. *J. Av. Med.*, Apr., 1953, p. 113. WADC Aero Medical Lab. research.

Microscopical Observations of Peripheral Circulation at Simulated High Altitudes. B. J. Sullivan and L. D. De Gennaro. *J. Av. Med.*, Apr., 1953, p. 131.

Discriminatory Analysis. X—On Two Correlated Bivariate Non-normal Distributions. Harry M. Hughes. *USAF SAM Project 21-49-004 Rep. 10*, Apr., 1952. 19 pp.

The Effect of Number of Dials on Qualitative Reading of a Multiple Dial Panel. Virginia L. Senders. *USAF TR 52-182*, Nov., 1952. 34 pp.

Investigation of Perceptual Factors Involved in the Interpretation of PPI-Scope Presentations. II—A Pilot Study on Form Discrimination. Siegfried J. Gerathewohl and David Rubinstein. *USAF SAM Project 21-24-009 Rep. 2*, Aug., 1952. 12 pp.

Luminance Thresholds For the Resolution of Visual Detail During Dark Adaptation Following Different Durations of Light Adaptation. Aaron L. Diamond and Alberta S. Gilinsky. *USAF TR 52-257*, Apr., 1952. 21 pp.

New Tests for the Examination and Training of Color Vision. III—Color Vision Multitester (Signal Lamp) for Aviation. Ingeborg Schmidt. *USAF SAM Project 21-29-006 Rep. 3*, Apr., 1952. 14 pp.

Time Threshold Perimetry. I—A Revolving Perimeter for Studying the Regional Sensitivity and Time Factors in Visual Sensation. Paul A. Cibis, Francis A. Brogan, and Horst G. Fleck. *USAF SAM Project 21-31-006 Rep. 1*, Apr., 1952. 10 pp.

Explosive Decompression. II—The Mechanical Effect of Multiple Explosive Decompressions. William L. Burkhardt, Charles K. Coulson, Dominic Criscuolo, and Harry F. Adler. *USAF SAM Project 21-23-005 Rep. 2*, Aug., 1951. 8 pp.

Physik und Physiologie des Drucksturzes im Weltenraum. Fr. Haber and H. Strughold. *Weltraumfahrt*, Oct., 1952, p. 118. Physics and physiology of explosive decompression in space.

Effectiveness of Various Drugs in Prevention of Airsickness. VIII—Evaluation of Various Techniques for Screening Anti-Motion-Sickness Drugs. Herman J. Chinn and Nicholas P. Plotnikoff. *USAF SAM Project 21-32-014 Rep. 8*, Dec., 1952. 4 pp.

The Effects of Certain Motion Sickness Preventives Upon Psychological Efficiency. Robert B. Payne, Edwin W. Moore, and James L. Bethurum. *USAF SAM Project 21-32-019 Rep. 1*, Aug., 1952. 23 pp.

Further Evaluation of Drugs for the Prevention of Seasickness. Herman I. Chinn, Stanley W. Handford, Paul K. Smith, Thomas E. Cone, Robert F. Redmond, James V. Maloney, and Cheves McC. Smythe. *USAF SAM-USN Joint Project 21-32-014 Rep. 10*, Dec., 1952. 9 pp. 30 refs.

Psychophysiological Effects of Cold. I—The Role of Skin-Temperature and Sensory Sensitivity in Manual Performance Decrement. Robert A. McCleary. *USAF SAM Project 21-1202-0004 Rep. 1*, Jan., 1953. 16 pp.

Temperature Changes in Humans During Exposure to Lowered Oxygen Tension in a Cool Environment. Arnold L. Brown, Jr., Gordon F. Vawter, and John P. Marbarger. *USAF SAM Project 21-23-013 Rep. 4*, Sept., 1952. 11 pp.

Computers

Computers, Statistics, and Mathematics. Arthur Rose, Joan A. Schilk, and R. Curtis Johnson. *Ind. & Eng. Chem.*, May, 1953, p. 933. 227 refs. Review of the literature.

Conversion of an Eleven-Digit Binary Number to Decimal Form by Switching. B. E. Swire. *Australia, ARL IN 53*, Oct., 1952. 17 pp.

Die Göttinger Elektronischen Rechenmaschinen. I—Allgemeines. L. Biermann and H. Billing. **II—Die Göttinger Bandgesteuerte Rechenmaschine G 1.** H. Billing, W. Hopmann, and A. Schlüter. *ZAMM*, Jan.-Feb., 1952, p. 48. In German. Max-Planck-Institute's research on electronic sequence-controlled computers; working principles of the Göttingen tape-controlled machine.

High-Speed Number Generator Uses Magnetic Memory Matrices. An Wang. *Electronics*, May, 1953, p. 200.

Making Machines Remember. Ira M. Sage. *Prod. Eng.*, Apr., 1953, p. 141. Memory devices applied to mechanical techniques.

Micro-Programming and the Design of the Control Circuits in an Electronic Digital Computer. M. V. Wilkes and J. B. Stringer. *Proc. Cambridge Philos. Soc.*, Apr., 1953, p. 230.

The Analog Computer. Dewitt H. Pickens. *Prod. Eng.*, May, 1953, p. 176. Electronic computer principles; applications.

Different Approach to Analog Computation. C. R. Bonnell. *Radio & TV News, Radio-Electronic Eng. Sect.*, May, 1953, p. 14. Electromagnetic torsional integrating systems.

A Fourier Analyzer. F. J. McDonal. *Rev. Sci. Instr.*, Apr., 1953, p. 272. Analog computer to provide frequency analyses of transient signals, including both amplitude and phase.

A High Speed Product Integrator. A. B. Macnee. *Rev. Sci. Instr.*, Mar., 1953, p. 207. An analog computer.

Simple Computer Automatically Plots Correlation Functions. Allen H. Schooley. *Tele-Tech*, May, 1953, p. 71. SIMCOR, an analog device.

Education & Training

A Guide for Determining Training Aid and Device Requirements. Douglas H. Fryer, Mortimer R. Feinberg, and Robert M. Tomlinson. *U.S., ONR Human Eng. TR SDC-383-04-1*, May 15, 1952. 20 pp.

Learning from Kinescopes and Films. Robert Jackson. *U.S., ONR Human Eng. TR SDC-20-TV-1*, Apr., 1952. 15 pp.

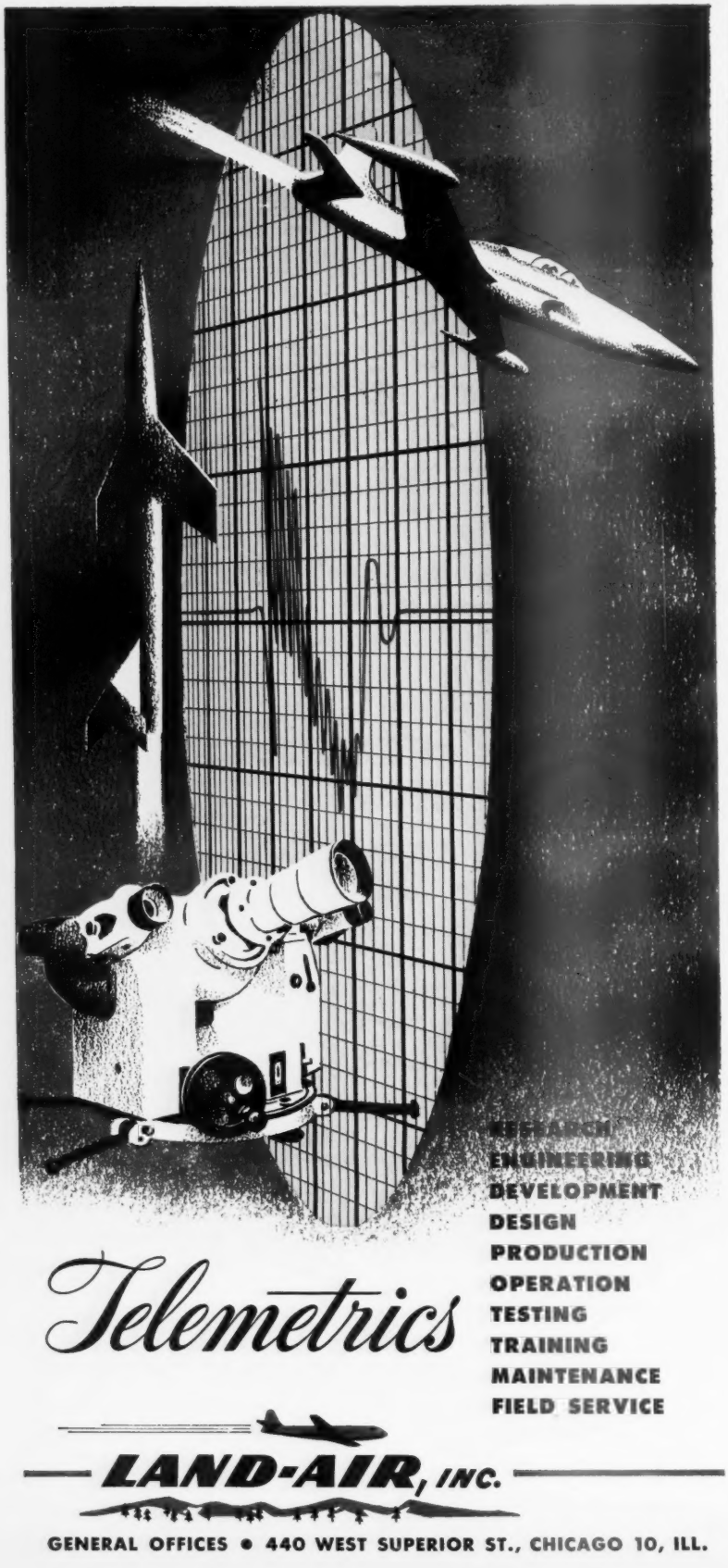
Electronics

Radio Progress During 1952. *Proc. IRE*, Apr., 1953, p. 452. 1057 refs. A review of the literature.

Remote Display of Radar Pictures; Design Requirements and Performance of a Centrimetric Radio Link. R. F. Hansford and G. J. Dixon. *Wireless World*, May, 1953, p. 218.

Electrical Telemetering and Automatic Process Control. I. J. R. Boundy. *Electronic Eng.*, Apr., 1953, p. 154.

Radio Telemetering. E. D. Whitehead and J. Walsh. (*IEE, Radio Sect. Paper 1389.*) *Proc. IEE, Part III*, Mar., 1953, p. 45; Discussion, p. 57. Principles of



various systems; characteristics of various types of modulation; multiplexing methods.

Time-Division Multiplex Systems. IV—Pulse-Code Modulation. J. E. Flood. *Electronic Eng.*, Apr., 1953, p. 146.

Antennas

New Antenna Fittings Reduce P-Static Interference. Charles De Vore. *Tele-Tech*, May, 1953, p. 77. NRL study to reduce aircraft radio precipitation static.

Optimum Patterns for Endfire Arrays. R. H. Duhamel. *Proc. IRE*, May, 1953, p. 652.

Theory of Artificial Slot Antennas. Adnan Ataman. *Istanbul Tech. U. Bul.*, No. 1, 1951, p. 71. 18 refs.

Circuits & Components

Design of Series Peaking Transformers. A. C. Sim. *Wireless Engr.*, Apr., 1953, p. 90.

Determination of Voltage, Current, and Magnetic Field Distributions together with the Self-Capacitance, Inductance and HF Resistance of Single-Layer Coils. Abd El-Samie Mostafa and M. K. Gohar. *Proc. IRE*, Apr., 1953, p. 537.

Maintenance Problems in New Airborne Radio Equipment. George H. Scheer, Jr. *Tele-Tech*, May, 1953, p. 88. Subminiaturization and other factors.

Nomographs for Designing Electromagnets. Keith W. Henderson. *Prod. Eng.*, May, 1953, p. 229.

Nonlinear Condensers; Ceramics with High Dielectric Constants. . . . B. G. Lewis. *Radio & TV News, Radio-Electronic Eng. Sect.*, May, 1953, p. 3.

Optimum Nonlinear Filters. L. A. Zadeh. *J. Appl. Phys.*, Apr., 1953, p. 396.

Reliability of Airborne Electronic Components. B. G. Bromberg and R. D. Hill, Jr. *Proc. IRE*, Apr., 1953, p. 513.

A 360 Degree Phase Shifter. Sidney Wald. *Radio & TV News, Radio-Electronic Eng. Sect.*, May, 1953, p. 32. Application to radar-range measuring, navigational, and other circuits.

Voltage Stabilization. I. F. A. Benson. *Electronic Eng.*, Apr., 1953, p. 160. 40 refs.

Cathode-Drift Compensation in D-C Amplifiers. J. W. Rittenhouse. *Elec. Eng.*, Apr., 1953, p. 299. Abridged.

Magnetic Amplifiers; Circuits, General Characteristics and Applications of Magnetic Amplifiers Reviewed and Compared to Electronic Amplifiers. I. Siegfried R. Hoh. *Tele-Tech*, May, 1953, p. 68.

Magnetic Amplifiers; What They Are and How They Are Applied in Electronic Control Systems for Machines. R. W. Roberts. *Mach. Des.*, Apr., 1953, p. 171.

Self-Balancing Potentiometer-Type Magnetic Amplifiers. W. A. Geyger. *Elec. Eng.*, Apr., 1953, p. 294. Abridged.

Survey of the Limits in DC Amplification. C. M. Verhagen. *Proc. IRE*, May, 1953, p. 615. 44 refs.

Theory of the Large Signal Behavior of Traveling-Wave Amplifiers. A. Nordsieck. *Proc. IRE*, May, 1953, p. 630.

The Algebraic Theory of Linear Transmission Networks. I. Maynard G. Arsove. *J. Franklin Inst.*, Apr., 1953, p. 301

How to Design Notch Networks. C. J. Savant, Jr. *Electronics*, May, 1953, p. 188. Application to feedback control systems.

The Measurement of "*A*" Matrix Elements of Passive Networks. W. R. Hinton. *Electronic Eng.*, April, 1953, p. 151.

Note on a Network Theorem. Leo Storch. *Wireless Engr.*, Apr., 1953, p. 77.

Optimum Linear Shaping and Filtering Networks. Raymond S. Berkowitz. *Proc. IRE*, Apr., 1953, p. 532.

Precision Transistor Oscillator. Peter G. Sulzer. *Radio & TV News, Radio-Electronic Eng. Sect.*, May, 1953, p. 18. NBS development. (Also in *Electronics*, May, 1953, p. 206.)

The Use of Admittance Diagrams in Oscillator Analysis. Herbert J. Reich. *Proc. IRE*, Apr., 1953, p. 522.

Components for Transistors; Low Operating Voltages and Currents Make Extreme Miniaturization Possible. G. W. A. Dummer. *Wireless World*, May, 1953, p. 196.

Some Transient Properties of Transistors. H. G. Bassett and J. R. Tillman. *Brit. J. Appl. Phys.*, Apr., 1953, p. 116.

Transistors. III—Earth-emitter and Earth-collector Circuits as Amplifiers and Oscillators. IV—Introduction to the Junction Transistor. Thomas Roddam. *Wireless World*, Apr., May, 1953, pp. 175; 205.

Transistors: Theory and Application. III—Physical Properties of Electrons in Solids. Abraham Coblenz and Harry L. Owens. *Electronics*, May, 1953, p. 162.

Transistors in Terms of Vacuum Tubes. Hans E. Hollmann. *Tele-Tech*, May, 1953, p. 74.

Electronic Controls

Automatic Relay Control. Eric Brooke. *Mach. Des.*, Apr., 1953, p. 154.

Circuits and Applications of Contactor Control Devices. Sidney Davis and Alfred Gronner. *Prod. Eng.*, Apr., 1953, p. 204.

Coulomb Friction in Feedback Control Systems. V. B. Haas, Jr. *Elec. Eng.*, May, 1953, p. 405. Abridged.

Feedback Control Opens New Horizons. Gordon S. Brown. (*AIEE Centennial of Eng. Meeting, Chicago, Sept., 1952, Paper.*) *Mach. Des.*, Apr., 1953, p. 386.

A Saturable-Core Reference Source for Use with Magnetic Amplifiers. A. G. Milnes and T. V. Vernon. *J. Sci. Instr.*, Apr., 1953, p. 135.

Some Relay Scaling Circuits. B. E. Swire. *Australia, ARL IN 52*, Nov., 1952. 54 pp.

Transient Measurements of Feedback Control Systems. F. H. Ferguson and C. H. Looney. *Elec. Eng.*, May, 1953, p. 444. Abridged.

Electronic Tubes

Conductance Curves Speed Triode R-C Amplifier Design. Keats A. Pullen. *Tele-Tech*, May, 1953, p. 80. Ballistics Research and other applications.

A Decimal Counter Electron Tube. D. L. Hollway. *Australian J. Phys.*, Mar. 1953, p. 96.

Genesis of a Generator—The Early History of the Magnetron. Robert L. Wathen. *J. Franklin Inst.*, Apr., 1953, p. 271. 38 refs. Survey of developments to 1950.

Grid Magnetron Delivers Modulated UHF Output. P. L. Spencer. *Electronics*, May, 1953, p. 148. Telemetering, radar, and other applications.

Improving Gas-Tube Grid Circuit Reliability. J. H. Burnett. *Elec. Eng.*, Apr., 1953, p. 341.

Inherent Feedback in Triodes. H. Stockman. *Wireless Engr.*, Apr., 1953, p. 94.

Luminance Thresholds For the Resolution of Visual Detail During Dark Adaptation Following Different Durations of Light Adaptation. Aaron L. Diamond and Alberta S. Gilinsky. *USAF TR 52-257*, Apr., 1952. 21 pp. Investigation on visual factors in cathode-ray-tube data presentation.

Measurements of Saturated-Diode Stability. V. H. Attree. *Brit. J. Appl. Phys.*, Apr., 1953, p. 114.

The Noise of Electronic Valves at Very High Frequencies. II—The Triode. G. Diemer and K. S. Knol. *Philips Tech. Rev.*, Feb., 1953, p. 236.

Positive and Negative Ions in Cathode-Ray Tubes. C. H. Bachman, G. L. Hall, and P. A. Silberg. *J. Appl. Phys.*, Apr., 1953, p. 427.

Precision Cathode Ray Tubes. R. D. Phillips. *Electronics Forum*, Sept., 1952, p. 4.

Work Functions of Gas-Coated Tungsten and Silver Surfaces. G. L. Weissler and T. N. Wilson. *J. Appl. Phys.*, Apr., 1953, p. 472.

Measurements & Testing

Combined Pirani and Ionization Gauge Circuit. G. von Dardel. *J. Sci. Instr.*, Apr., 1953, p. 114.

Crystal Impedance Meters Replace Test Sets. A. C. Prichard and M. Bernstein. *Electronics*, May, 1953, p. 176. Development for the Armed Forces.

The Function and Design of Transducers for Oscillography. I, II. Mark T. Nadir. *The Oscillographer*, July–Aug., Aug.–Dec., 1952, pp. 3; 3.

The Investigation of Ionospheric Absorption by a New Automatic Method. I—Measurements on Vertical-Incidence Pulse Signals. J. B. Jenkins and G. Ratcliff. *Electronic Eng.*, Apr., 1953, p. 140.

The Measurement of the Phase Velocity of Ground-Wave Propagation at Low Frequencies over a Land Path. B. G. Pressey, G. E. Ashwell, and C. S. Fowler. (*IEE, Radio Sect. Paper 1438.*) *Proc. IEE, Part III*, Mar., 1953, p. 73. Using transmissions from English chain of the Decca Navigator System.

Measuring Wavelength in Millimeters. John R. Martin and Carl F. Schunemann. *Electronics*, May, 1953, p. 184. Application of optical methods using Boltzmann and Michelson interferometers and diffraction grating spectrometer.

New Equipment for Impedance Matching and Measurement at Very High Frequencies. A. Bloch, F. J. Fisher, and G. J. Hunt. (*IEE, Radio Sect. Paper 1409.*) *Proc. IEE, Part III*, Mar., 1953, p. 93.

A Retarding Potential Method for Measuring Electrical Conductivity of Oxide-Coated Cathodes. I. L. Sparks and H. R. Philipp. *J. Appl. Phys.*, Apr., 1953, p. 453.

Navigation Aids

Automatic Cruise-Control Computer for Long-Range Aircraft. J. R. Shull. *Elec. Eng.*, Apr., 1953, p. 309.

Laboratory Tests of VOR Signal Interference Ratios. Raymond A. Forcier and W. L. Seibert. *U.S., CAA TDR 154*, Mar., 1953. 6 pp.

A VOR-DME Simulator for Link Trainers. Edward M. Blount, Hugh A. Kay, and Raymond E. McCormick. *U.S., CAA TDR 193*, Mar., 1953. 12 pp.

Noise & Interference

Fluctuation Noise in a Microwave Superregenerative Amplifier. Theodore S. George and Harry Urkowitz. *Proc. IRE*, Apr., 1953, p. 516.

Interference Between VHF Navigation Receivers. David S. Crippen and W. L. Seibert. *U.S., CAA TDR 132*, Apr., 1953. 4 pp.

Noise in Thermionic Valves. J. H. Fremlin. (*IEE, Radio Sect. Paper 1491.*) *Proc. IEE, Part III*, Mar., 1953, p. 91.

Peak-Noise Characteristics of Some Glow-Discharge Tubes. H. Bache and F. A. Benson. *J. Sci. Instr.*, Apr., 1953, p. 124.

Standards on Sound Recording and Reproducing Methods of Measurement of Noise, 1953. A. G. Jensen, A. W. Friend, A. P. G. Peterson, and others. *Proc. IRE*, Apr., 1953, p. 508.

Statistical Criteria for the Detection of Pulsed Carriers in Noise. I, II. David Middleton. *J. Appl. Phys.*, Apr., 1953, pp. 371; 379.

Transmission Lines

High-Powered Microwave (Waveguide) Dummy Loads. Tore N. Anderson. *Tele-Tech*, May, 1953, p. 92. Aircraft, radar, and military testing and operation.

The Susceptance of a Circular Obstacle to an Incident Dominant Circular-Electric Wave. L. S. Sheingold. *J. Appl. Phys.*, Apr., 1953, p. 414.

Waveguide Attenuation and Its Correlation with Surface Roughness. F. A. Benson. (*IEE, Radio Sect. Paper 1467.*) *Proc. IEE, Part III*, Mar., 1953, p. 85.

Wave Propagation

Improved Meteorological Soundings. *U.S., NBS Sum. TR 1758*, Apr., 1953. 4 pp. NBS-designed electronic "wiredsonde" system for use in measuring radiowave propagation.

A Low-Frequency Ionosphere Recorder. *U.S., NBS Sum. TR 1755*, Mar., 1953. 6 pp. NBS-developed 50–1100 kc. radio wave propagation recorder.

A Review of Present Knowledge of the Ionospheric Propagation of Very-Low, Low- and Medium-Frequency Waves. F. A. Kitchen, B. G. Pressey, and K. W. Tremellen. (*IEE, Radio Sect. Paper 1463.*) *Proc. IEE, Part III*, Mar., 1953, p. 100. 70 refs.

LEADERSHIP DEMANDS CONSTANT ACHIEVEMENT

Starfire efficiency means Air Force economy

The United States Air Force is economy minded. Yet it must and does expect superlative performance from its aircraft.

Take a look at how the Air Force's new all-weather fighter-interceptor, the F-94C Starfire, fills the bill on both counts—performance *and* economy.

Recent operation under tactical conditions shows that the Starfire is a rugged, reliable plane that averages many working hours in the air between servicings. This cuts maintenance costs throughout the life of each plane—a sizable cumulative saving. Furthermore, Starfires are *easy* to service and are therefore quickly back on duty. Less frequent service plus quicker service means *more flying time per plane*, so that fewer total planes are needed by the Air Force—another sizable saving.

At the same time the U.S.A.F. Starfire gives top performance in any weather, night or day. No other fighter-interceptor can reach enemy bomber level faster from a cold start. No other has finer automatic equipment—Hughes Radar System, Westinghouse Automatic Pilot, Sperry Zero Reader, Lockheed Rocket Release. And the F-94C is easy to fly and rock-steady under instrument conditions.

In addition the Lockheed Starfire is a 2-place interceptor, thus utilizing the cooperative efficiency of a 2-man team to perform all the split-second operations of intercepting an enemy (possibly unseen) at 600-mph-plus speeds.

F-94C Starfire

Lockheed *Aircraft Corporation*

BURBANK, CALIFORNIA, AND MARIETTA, GEORGIA

LOOK TO LOCKHEED FOR LEADERSHIP

Lockheed

Starfire Scores First Night Kill on MIG-15

Burbank, Calif.—(Special)—The F-94 Starfire has scored the first night victory over a Russian MIG-15, according to U.S. Air Force dispatches from Korea.

The Air Force announcement was the first disclosure that Lockheed F-94 Starfires were on duty in Korea. Designed essentially for round-the-clock, round-the-calendar home defense, these almost-automatic radar interceptors are proving to be as versatile as other Lockheed jets, including the famous F-80 Shooting Star, America's first operational jet fighter.

Lockheed's jet fighter record in Korea began *when the F-80 Shooting Star became the first airplane ever to shoot down a Russian MIG*. Later, the Shooting Star was assigned a multitude of missions—napalm bombing, ground-support strafing, bombing with 500-pound bombs, aerial interception, photo reconnaissance, close interdiction and many others. In the first year **Lockheed Shooting Stars had flown more missions than all other allied aircraft combined.**

Now the Shooting Star's younger but more powerful brother, the F-94 Starfire, is proving equally versatile both in Korea and at home, where it is on alert to protect major cities from air attack.

Lockheed builds U. S. defense team

Lockheed F-94 Starfires are just one member of the "defense of America" team now in production at Lockheed:

Lockheed T-33 and TV-2 Jet Trainers, in which 9 out of 10 U.S.A.F. and Navy jet pilots are trained, are being turned out at the fastest rate in history following installation of a mechanized final assembly line at Lockheed's Van Nuys, Calif., factory.

Navy P2V Patrol Bombers, holders of the world's distance record, now have improved radar and armaments, expanding their versatility from anti-submarine patrol to long-range reconnaissance.

Super Constellation Transports designed for new turbo-prop power are now in production for special Navy assignments. Other Super Constellations with turbo-compound engines are being produced for Air Force troop transport, hospital planes and cargo.

WV-2 Super Constellations, early-warning aircraft for the Navy, apply an entirely new concept of national defense which expands radar's eyes and ears far beyond the horizon.

B-47 Jet Bombers, designed by Boeing, are being produced for the Air Force at Lockheed's big Marietta, Georgia, plant.

The C-130 Turbo-prop Cargo Transport is the first all-cargo plane designed from the ground up for high-speed turbo-prop power—now tooling for production at Marietta and Burbank.

Today's advanced production is only a part of Lockheed's present concern. For in the Lockheed laboratories at Burbank and Van Nuys, California, as well as Marietta, Georgia, scientists pry deeper into the mysteries of new types of power, new guidance systems, new and lighter and stronger alloys to answer the demands of tomorrow's science of flight.

A Review of VHF Ionospheric Propagation. M. G. Morgan. *Proc. IRE*, May, 1953, p. 582. 67 refs.

Tropospheric Propagation: A Selected Guide to the Literature. IRE Wave Propagation Committee. *Proc. IRE*, May, 1953, p. 588. 41 refs.

Equipment

Aluminum Tanks and Pressure Vessels. . . . E. V. Sharpnack, Sr. *Prod. Eng.*, Apr., 1953, p. 183.

Metallurgical Aspects of Aircraft Heaters. II—The Development of X-Ray Standards For Welds in Aircraft Heaters and Components. *Aircraft Heating Dig.*, Dec., 1952, p. 1.

A Simple High-Speed Air Spinner for Centrifugal Testing of Small Mechanical Devices. C. F. Bild and P. F. Vial. *Trans. ASME*, May, 1953, p. 515.

Electric

Electrical Circuits for Adding Strain Gauge Signals; An Investigation of Modified Wheatstone Bridge Circuits. E. H. Mansfield. *Aircraft Eng.*, Apr., 1953, p. 108.

Electrical Equipment for Turbo, Rotary, and Reciprocating Compressors. W. Schöni. *Brown Boveri Rev.*, Aug.-Sept., 1952, p. 306.

Maintenance of Aircraft Electrical Equipment. J. H. M. Sykes. *Interavia*, No. 4, 1953, p. 209.

Maintenance of Electric Equipment in Modern Aircraft. A. J. Mustard. *Elec. Eng.*, Apr., 1953, p. 312.

Remote Rotational Positioning. C. S. Allen and Harris Shapiro. *Mach. Des.*, Apr., 1953, p. 243. Star-Kimble Motor Div.'s d.c. device.

Hydraulic & Pneumatic

Control of Hydraulic Shock in Aircraft Lines. C. E. Adams. *Appl. Hydraulics*, May, 1953, p. 102.

Design and Application of Controlled-Volume Pumps for High Pressure in the Range of 10,000 to 30,000 Psi. D. H. Jones. *Trans. ASME*, Apr., 1953, p. 361.

Flareless Fittings. X. R. W. Phillips. *Appl. Hydraulics*, May, 1953, p. 84. Aircraft fittings.

High-Pressure Pneumatics; Design Considerations for Maximum Efficiency in Energy Storage. James L. Dooley. *Mach. Des.*, Apr., 1953, p. 237.

High-Pressure Pumps. U. M. Barske. *The Engr.*, Apr., 1953, p. 550. Hollow impeller and open impeller pumps; hydrodynamic design problems.

Hydraulic Control Systems. R. Hadekel. *Mach. Des.*, Apr., 1953, p. 185. General circuit problems; design considerations; live and dead systems; power economy and energy storage; control of load speed and position; applications.

Contribution to the Hydraulic Losses in T-Connections of Various Angles. Emil Kinne. (*Mitteil. Hydraulischen Inst. Tech. Hochschule, München*, Heft IV, 1931, p. 70.) *Sverdrup & Parcel Transl. Rep. X-4*, Mar. 10, 1953, 41 pp.

Investigation of the Losses in Oblique Angled Pipe Joints (Oblique Angle = 45°). Franz Petermann. (*Mitteil. Hydrauli-*

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schen Inst. Tech. Hochschule, München, Heft III, 1929, p. 98.) *Sverdrup & Parcel Transl. Rep. X-3*, Mar. 9, 1953. 39 pp.

Investigations of the Losses in Right Angle Pipe Joints. I—Main Pipe Larger than Branch Pipe Diameter. II—Main Pipe and Branch Pipe Same Diameter. Gustav Vogel. (*Mitteil. Hydraulischen Inst. Tech. Hochschule, München*, Heft I, 1926, p. 75; Heft II, 1928, p. 61.) *Sverdrup & Parcel Transl. Rep. X-1, X-2*, Feb. 17, 18, 1953, 35; 7 pp.

Hydraulics in Modern Aircraft. George Tate. *Can. Av.*, Apr., 1953, p. 79.

Pilot Operated Air Control Systems. H. L. Stewart. *Prod. Eng.*, May, 1953, p. 214.

Resistance Effects on Hydraulic Instability. R. F. Dressler and F. V. Pohle. *Commun. on Pure & Appl. Math.*, Feb., 1953, p. 93.

Seals to Minimize Leakage at Higher Pressure. B. A. Niemeier. *Trans. ASME*, Apr., 1953, p. 369.

Flight Operating Problems

Some Investigations & Problems Encountered with Aircraft Operated in India. C. W. Rossiter-Smith. *J. Aero. Soc. India*, Feb., 1953, p. 14. Includes study of the sand-dust and lubrication problems.

In-flight Fuelling Methods. Peter Berry. *Aeronautics*, Apr., 1953, p. 63. Survey of three techniques.

Ice Prevention & Removal

The Frequency Response and the Transfer Functions of the Human Pilot. G. M. Andrew. *USAF FTC TR 52-28*, Mar., 1953. 36 pp. Flight Test Center, Edwards AFB, Calif., studies on piloting techniques and skills.

On the Noise Emanating from a Two-Dimensional Jet Above the Critical Pressure. Alan Powell. *Aero. Quart.*, Feb., 1953, p. 103.

A Method for Determining Cloud-Droplet Impingement on Swept Wings. Robert G. Dorsch and Rinaldo J. Brun. *U.S., NACA TN 2931*, Apr., 1953. 29 pp.

Orifice-Type Ice Detector; Preliminary Icing Tunnel Tests of Functioning As Ice Detector, Rate-of-Icing Meter, and Icing-Severity Meter. D. Fraser. *Canada, NAE LR-3*, July, 1951. 23 pp.

Flight Safety & Rescue

Experimental Investigation of the Effect of Rear-Fuselage Shape on Ditching Behavior. Ellis E. McBride and Lloyd J. Fisher. *U.S., NACA TN 2929*, Apr., 1953. 35 pp.

Radar and the Collision Problem. James Q. Brantley, Jr. *Skyways*, June, 1953, p. 14. Cornell Aero. Lab. and other studies.

Fuels & Lubricants

Fluid-Borne Solid Particles with Particular Reference to Solid Fuel for Internal Combustion Engines. John S. Moloney. *Eng. J.*, Apr., 1953, p. 395. McGill University Gas Dynamics Lab. studies.

Free Fall and Evaporation of *n*-Octane Droplets in the Atmosphere as Applied to

the Jettisoning of Aviation Gasoline at Altitude. Herman H. Lowell. *U.S., NACA RM E52L23a*, Apr. 28, 1953. 25 pp.

Polarographic Studies in Sulfur Compounds in Petroleum Fractions. Maynard E. Hall. *Anal. Chem.*, Apr., 1953, p. 556.

Lubricants & Lubrication

Aircraft Lubrication. I, II. Kenneth C. Hunt. *J. SLAE, Tech. Instructor* Sect., Feb., Mar., 1953, pp. 8; 11.

Basic Properties of Lubricating Greases. C. J. Boner. *Mach. Des.*, May, 1953, p. 129.

Metal Transfer during Static Loading and Impacting. E. Rabinowicz. *Proc. Phys. Soc., Sect. B*, 1952, p. 630. Reprint. Friction and lubrication studies.

Viscosité sous Pression Rapidement Variable. Fernand Charron. *France, Min. de l'Air PST 268*, 1952. 30 pp. In French. Experimental study of viscosity of lubricants under rapidly changing pressure.

Propellants

A Study of Detonative Phenomena in Gaseous Mixtures by the Use of Shock Tube Techniques. Richard B. Morrison. *ASME Semi-Annual Meeting, Cincinnati, June 15–19, 1952, Paper 52-SA-20.* 13 pp.

Volumetric Behavior of Red and White Fuming Nitric Acid. H. H. Reamer, D. M. Mason, and B. H. Sage. *Ind. & Eng. Chem.*, May, 1953, p. 1094.

Wie soll man das Mischungsverhältnis eines Treibstoffes angeben? U. T. Bödewadt. *Weltraumfahrt*, Oct., 1952, p. 123. On the mixture ratio of liquid propellants.

Gliders

The Answer to Mr. Fletcher's Prayer? I—The "LO-100" Zwergreiher ("Dwarf Heron"). II—"Kaiser Ka-1." III—"Tondo Kuro III," 1937. IV—The "Kobold." V—Hutter-30 Project. VI—"Spatz." *Sailplane & Glider*, Apr., 1953, p. 11.

Instruments

Design of a Square-Root-Extracting, Force-Balance, Pneumatic Transmitter, Including Derivation of Formulas. Arnold Goldberg. *Trans. ASME*, May, 1953, p. 501. Design of a flowmeter that measures the differential pressure developed across an orifice, or other primary element, and puts out an air pressure directly proportional to the flow rate.

Interpretation of Accelerometer Readings for Curvilinear Motion. R. Sedney. *Douglas Rep. SM-14588*, Dec. 5, 1952. 16 pp.

Metal Ebulliometers for Vapor Pressure Measurement. George D. Oliver and J. W. Grisard. *Rev. Sci. Instr.*, Mar., 1953, p. 204.

A Simple Thrust Indicator for Propeller-Driven Airplanes. A. W. Vogeley and M. N. Gough. *Aero. Eng. Rev.*, June, 1953, p. 47.

A Six-Channel Recorder. A. L. Whitwell. *Electronic Eng.*, Apr., 1953, p. 134.

Off-On Modulated Reversing Clutch Servo Systems. T. R. Stuelpnagel and J. P. Dallas. *Elec. Eng.*, May, 1953, p. 430.

An Improved Magnetic Servo Amplifier. C. W. Lufcy, A. E. Schmid, and P. W. Barnhart. *Elec. Eng.*, Apr., 1953, p. 308. Abridged.

A Machine for Tensile Testing at Controlled Temperatures and Constant True Strain Rates. E. L. Bartholomew, Jr., K. J. Krystyan, D. A. J. Millar, and J. Wulff. *Rev. Sci. Instr.*, Mar., 1953, p. 196.

Temperature-Measuring Devices

An Apparatus for Measuring the Coefficient of Thermal Conductivity of Solids and Liquids. T. A. Marshall. *Brit. J. Appl. Phys.*, Apr., 1953, p. 112.

Fast Thermocouples As Control System Elements Sensing Exhaust Gas Temperature in Aircraft Gas Turbines. J. S. Alford and C. R. Heising. *ASME Semi-Annual Meeting, Cincinnati, June 15–19, 1952, Paper 52-SA-35.* 14 pp.

Sonic-Flow-Orifice Temperature Probe in High-Gas Temperature Measurement. Perry L. Blackshear, Jr. *ASME Semi-Annual Meeting, Cincinnati, June 15–19, 1952, Paper 52-SA-38.* 10 pp.

Stability of a Bimetallic Disk. I. W. H. Wittrick. **II.** W. H. Wittrick, D. M. Myers, and W. R. Blunden. *Quart. J. Mech. & Appl. Math.*, Mar., 1953, p. 15. General theory of the deformation of bimetallic discs undergoing temperature changes; application to the spherical cap form used as a thermostat control element.

A Temperature-Sensitive Phosphor Used to Measure Surface Temperatures in Aerodynamics. Lee C. Bradley, III. *Rev. Sci. Instr.*, Mar., 1953, p. 219.

Laws & Regulations

Land Damage Liability in Aircraft Cases. John Augustine Eubank. *Dickinson Law Rev.*, Mar., 1953, p. 188. Reprint.

Machine Elements

Improving Fatigue Resistance of Bolted Joints. J. P. Vidosic. *Prod. Eng.*, Apr., 1953, p. 190.

A New Approach to Compression Spring Design. K. W. Maier. *Prod. Eng.*, May, 1953, p. 154.

Bearings

On the Solution of the Reynolds Equation for Slider-Bearing Lubrication. III—Effect of Transverse Curvature. A. Charnes, E. Sabiel, and A. S. C. Ying. *Trans. ASME*, May, 1953, p. 507.

Les Roulements Timken Appliqués aux Appareils à Voilures Tournantes (Timken Bearings Applied to Rotary-Wing Machines). Robert de Beauvivier. *Tech. et Sci. Aéronautiques*, No. 1, 1952, p. 24. In French.

Selection and Application of Roller Bearings. Kenneth N. Mills. *Mach. Des.*, Apr., 1953, p. 248.

Gears & Cams

Contribution à l'Étude de la Résistance à la Fatigue des Dents d'Engrenage (Contribution to the Study of the Resistance to Fatigue of Gear Teeth). R. Devillers. *Tech. et Sci. Aéronautiques*, No. 3, 1952, p. 189. In French.

Design Instrument Gear Trains for Precise Operation and Lower Cost. Louis D. Martin. *Mach. Des.*, May, 1953, p. 120.

Eccentric Gear Mechanisms for Producing Varying Angular Velocity with Circular Spur Gears. Paul Grodzinski. *Mach. Des.*, May, 1953, p. 141.

Rotating Discs & Shafts

Angle-True Motion Provided by Orthodromic Mechanisms for Connecting Parallel Shafts in Precision Applications. Michael Daniloff. *Mach. Des.*, May, 1953, p. 153.

Fully Plastic Rotating Disc with Large Strains. Melvin Zaid. *J. Aero. Sci.*, June, 1953, p. 396.

The Stress Distribution in a Shaft Press-Fitted with a Collar. H. Ōkubo. *ZAMM*, June, 1952, p. 178. Investigation of the two-dimensional problem of an elastic foundation compressed by a pillar with a rectangular cross section.

Materials

De Afscheurproef van Gelijmd Licht Metaalplaat. I. A. Hartman. *Netherlands, NLL Rep. M. 1893*, Jan. 10, 1952. 50 pp. In Dutch. Determination of the mean value and scatter of the peeling strength of redux-bonded 24ST-alclad sheet, 0.8 mm. thickness, under standard conditions.

Application des Sondes Electroniques à une Méthode d'Analyse Ponctuelle Chimique et Cristallographique (Application of Electronic Sounds to a Method of Exact Chemical and Crystallographic Analysis). R. Castaing. *France, ONERA Pub. 55*, 1952. 92 pp. 36 refs. In French.

Electrical Phenomena in Adhesion. I—Electron Atmospheres in Dielectrics. Selby M. Skinner, Robert L. Savage, and John E. Rutzler, Jr. *J. Appl. Phys.*, Apr., 1953, p. 438. Application to bonded materials.

Engravement of Transient Stress Wave Particle Velocities. John S. Rinehart and John Pearson. *J. Appl. Phys.*, Apr., 1953, p. 462. A method of obtaining quantitative information on the high intensity transient waves set up by impulsive loading in order to design against failure under such loads.

High-Density Alloys for Heavy-Weight Applications. Kenneth Rose. *Materials & Methods*, Apr., 1953, p. 86.

On the Generality of the Cubic Creep Function. A. J. Kennedy. *J. Mech. & Phys. Solids*, Mar., 1953, p. 172.

Corrosion & Protective Coatings

"Araldite" Surface Coating Resin 985 E; An Ethoxyline Resin for the Protection of Metal Surfaces. *Aero. Res. TN Bull. 123*, Mar., 1953. 8 pp.

Colloidal and Surface Phenomena. Geoffrey Broughton. *Ind. & Eng. Chem.*, May, 1953, p. 912. 912 refs. Review of the literature.

Corrosion Resistance of Titanium, Zirconium, and Stainless Steel in Organic Compounds. I. R. Lane, Jr., L. B.

Golden, and W. L. Acherman. *Ind. & Eng. Chem.*, May, 1953, p. 1067.

Electroless Nickel Plating: Where It Stands Today. John B. Campbell. *Materials & Methods*, May, 1953, p. 96. Advantages, limitations, and costs; properties; applications.

Influence of Organic Detergents on Metal Corrosion. T. K. Ross. *Metal Treatment*, Apr., 1953, p. 183.

Relation Between Roughness of Interface and Adherence of Porcelain Enamel to Steel. J. C. Richmond, D. G. Moore, H. B. Kirkpatrick, and W. N. Harrison. *U.S., NACA TN 2934*, Apr., 1953. 29 pp.

Metals & Alloys

The Diamagnetism of Quasi-Bound Conduction Electrons. A. H. Wilson, *Proc. Cambridge Philos. Soc.*, Apr., 1953, p. 292. Application to problems in the theory of metals.

A Dictionary of Metallurgy. XV—FOGA. A. D. Merriman and J. S. Bowden. *Metal Treatment*, Apr., 1953, p. 163.

Die Pressure in Plane Strain Drawing: Comparison of Experiment with Theory. J. G. Wistreich. *J. Mech. & Phys. Solids*, Apr., 1953, p. 164. Investigation on metals with widely differing work-hardening rates.

Diffusion and Oxidation of Solid Metals. C. E. Birchenall. *Ind. & Eng. Chem.*, May, 1953, p. 907. 103 refs. Review of the literature.

Die Ermüdung der Metalle. M. Roš. *ZAMM*, Apr.-May, 1952, p. 130. In German. Investigation into the fatigue of metals under varying conditions; development of a uniform version of the theory of breaking for static and dynamic stresses.

Étude des Perturbations Cristallines Produites dans les Métaux par des Efforts Alternés. Paul Laurent. *France, Min. de l'Air PST 256*, 1952. 116 pp. In French. Study of crystalline disturbances produced in metals by alternating stresses.

Hardening of Metals. J. L. Meijering. *Philips Tech. Rev.*, Jan., 1953, p. 203.

Influence des Grandes Vitesses de Déformation sur les Propriétés Mécaniques des Métaux (Influence of Great Rates of Deformation on the Mechanical Properties of Metals). Yves Pironneau. *Tech. et Sci. Aéronautiques*, No. 4, 1952, p. 224. In French.

Machinability of Metal Powder Parts. John L. Everhart. *Materials & Methods*, Apr., 1953, p. 98.

Materials & Methods Manual No. 93: Magnetic Materials. G. H. Stearley. *Materials & Methods*, Apr., 1953, p. 115. Nonretentive, permanent, and special property types; characteristics of nonmagnetic ferrous alloys.

The Mechanism of Work-hardening of Metals (The 39th Thomas Hawksley Lecture). N. F. Mott. *IME Proc. (A)*, No. 4, 1952, p. 413. 40 refs.

Metal Powder Filters. A. J. Langhammer and Phillip Glick. *Prod. Eng.*, Apr., 1953, p. 179.

The Role of Preferred Orientation in Elasticity Investigations. G. Bradfield and H. Pursey. *Philos. Mag. (7th Ser.)*, Apr., 1953, p. 437. National Physical Lab., Teddington, studies.

Selecting Forging Alloys. Lester Spencer. *Prod. Eng.*, May, 1953, p. 202. Characteristics and mechanical properties of steels, copper, aluminum, and magnesium alloys.

Some Problems on the Theory of Creep. Y. N. Rabotnov. (*Vestnik Moskovskovo Universiteta*, No. 10, 1948, p. 81.) *U.S., NACA TM 1353*, Apr., 1953. 19 pp. Translation.

Utilisation des Alliages Légers à Haute Résistance (Utilization of Light Alloys of Great Strength). F. Vinsonneau. *Tech. et Sci. Aéronautiques*, No. 4, 1952, p. 205. In French.

Metals & Alloys, Ferrous

Chromizing Improves Surface Properties of Steels. Richard P. Seelig. *Materials & Methods*, May, 1953, p. 106. The Chromalloy process; corrosion, wear- and heat-resistant, and other properties of chromized metals; applications.

Contribution à l'Étude de la Sursaturation du Fer en Hydrogène Cathodique. Jean Duflot. *France, Min. de l'Air PST 265*, 1952. 58 pp. 42 refs. In French.

The Effect of Specimen Geometry on Impact Transition Temperature. R. S. Zeno and J. L. Dolby. *Welding J., Res. Suppl.*, Apr., 1953, p. 190-s.

Properties and Manufacture of Valve Steels for the Automatic Industry. J. Cameron. *Metal Treatment*, Apr., 1953, p. 149. Use in internal-combustion engines.

Steels for High Temperature Service. Peter Payson. *Steel Processing*, Apr., 1953, p. 168.

Metals & Alloys, Nonferrous

ASARCO Continuous-Cast Bearing Bronzes. J. S. Smart, Jr., and Paul J. Kranz. *Mech. Eng.*, Apr., 1953, p. 287. Physical properties; dry-wear tests.

Determination of Aluminum in Zirconium; Based on Separation by Ion Exchange. Harry Freund and Frend John Miner. *Anal. Chem.*, Apr., 1953, p. 564.

Gravimetric Methods for Zinc and Its Separation from Certain Elements; Use of a Radioisotope in Evaluation of Analytical Procedures. John E. Vance and Richard E. Borup. *Anal. Chem.*, Apr., 1953, p. 610.

Plastic Flow in Lead Extrusion. C. T. Yang and E. G. Thomsen. *Trans. ASME*, May 1953, p. 575.

Properties of Electrodeposited Nickel... and What Influences Them. William A. Blum. *Materials & Methods*, Apr., 1953, p. 101.

Axial-Load Fatigue Properties of 24S-T and 75S-T Aluminum Alloy as Determined in Several Laboratories. H. J. Grover, W. S. Huyler, Paul Kuhn, Charles B. Landers, and F. M. Howell. *U.S., NACA TN 2928*, May, 1953. 63 pp.

Fluorometric Determination of Aluminum; Use of 8-Quinolinol. Edward Goon, Joseph E. Petley, Warren H. McMullen, and Stephen E. Wiberley. *Anal. Chem.*, Apr., 1953, p. 608.

Métallographie de l'Aluminium et de ses Alliages; Emploi du Polissage Électrolytique (Metallography of Aluminum and Aluminum Alloys; Use of Electrolytic Polishing). P. A. Jacquet. *France, ONERA Pub. 51*, 1952. 64 pp. 45 refs. In French.

The New Metal, Titanium: Its Application and Processing. R. W. Parcel. *SAE Summer Meeting, Atlantic City, N.J., June 1–6, 1952, Preprint 772.* 11 pp.

Titanium—A Survey. P. L. Teed. *J. RAeS.*, Apr., 1953, p. 189; Discussion, p. 207. 25 refs. Properties and possibilities; alloy characteristics; applications.

Il Titanio, Le Leghe a Base di Titanio e Le Loro Applicazioni Nelle Costruzioni Aeronautiche (Titanium, Titanium Alloys, and Their Application [in] Aircraft Construction). Riccardo Masaniello Corelli. *L'Aerotecnica*, Feb. 15, 1953, p. 27. In Italian.

Nonmetallic Materials

Effects of Very High Pressures on Glass. P. W. Bridgman and I. Šimon. *J. Appl. Phys.*, Apr., 1953, p. 405.

New Glass Fiber Mat Has Controlled Resiliency. Kenneth Rose. *Materials & Methods*, Apr., 1953, p. 176. Application to aircraft motor shock-absorbing mounts, instruments, and vibration muffling.

Effect of Preloading and Fatigue on Mechanical Properties of Glass-Cloth Plastic Laminates. A. D. Freas. *Trans. ASME*, May, 1953, p. 621.

Mechanical Properties of Glass-Cloth Plastic Laminates as Related to Direction of Stress and Construction of Laminate. Fred Werren. *Trans. ASME*, May, 1953, p. 613.

Automotive Uses Featured at Reinforced Plastics Conference. Thomas Mac New. **I—Plastic Helicopter Research.** K. Telford Marshall. **II—High Temperature Phenolics.** William E. Braham. **III—Glass Fiber—Polyester Molding Materials.** Albert G. H. Dietz. **IV—Reinforced Plastics in Aircraft Design.** W. G. Ramke. **V—Effect of Moisture Absorption.** Jay M. Stevens. *Auto. Ind.*, Apr. 1, 1953, p. 52. Abridged.

Fluorocarbon Plastics—What They Can Do—Where to Use Them. Philip O'Keefe. *Materials & Methods*, Apr., 1953, p. 110.

Polarographic Determination of Phthalate Esters in Plastics. Gerald C. Whitnack and E. St. Clair Gantz. *Anal. Chem.*, Apr., 1953, p. 553.

Properties and Characteristics of Foamed Plastic Materials. H. J. Stark. *Prod. Eng.*, Apr., 1953, p. 166.

Theory of Extrusion; A Symposium at ACS 122nd Meeting, Atlantic City, N.J. I—Basic Concepts of Extrusion. J. F. Carley and R. A. Strub. **II—Simplified Flow Theory for Screw Extruders.** J. F. Carley, R. S. Mallouk, and J. M. McKelvey. **III—Application of Theory to Design of Screw Extruders.** J. F. Carley and R. A. Strub. **IV—Experimental Studies of Melt Extrusion.** J. M. McKelvey. **V—Power Requirements of Melt Extruders.** R. S. Mallouk and J. M. McKelvey. **VI—Extruder Scale-Up Theory and Experiments.** J. F. Carley and J. M. McKelvey. **VII—Future Extrusion Studies.** C. H. Jepson. *Ind. & Eng. Chem.*, May, 1953, pp. 969; 974; 978; 982; 987; 989; 992. 33 refs.

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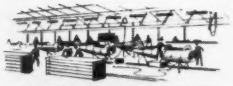

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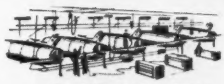

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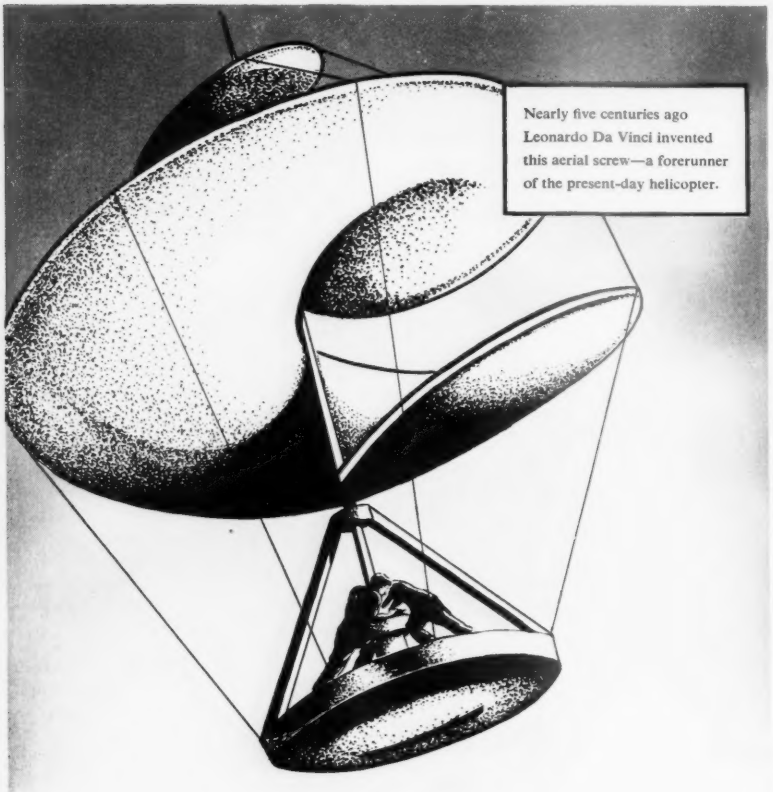

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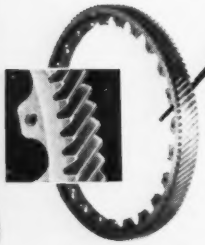

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Transitions in Teflon. *U.S., NBS Sum. TR 1763,* Apr., 1953. 4 pp. Results of NBS investigations; fundamental properties; application to aircraft parts such as gaskets, washers, and valve packings.

Über die Charakteristiken des Vollständigen Ebenen Plastizitätsproblems. Hilda Geiringer. *ZAMM,* Nov.-Dec., 1952, p. 379. In German. A general complete problem for an isotropic ideally plastic material with characteristics of tension and celerity which do not coincide and which do not halve the angles of the main lines.

Vacuum Formed Thermoplastics for Large, Thin Parts. Kenneth Rose. *Materials & Methods,* May, 1953, p. 94.

Direct Determination of Oxygen in Rubber; Comparison between Isotopic and Schütze-Unterzaucher Methods. A. D. Kirshenbaum and A. G. Streng. *Anal. Chem.,* Apr., 1953, p. 638.

Physical Properties of Oil-Enriched Rubbers. K. V. Weinstock, E. B. Storey, and J. S. Sweeley. *Ind. & Eng. Chem.,* May, 1953, p. 1035.

Stress Relaxation in Compression of Rubber and Synthetic-Rubber Vulcanizates Immersed in Oil. J. R. Beatty and A. E. Juva. *Trans. ASME,* May, 1953, p. 605.

Where Electrically Conductive Rubbers Are Proving Useful. Philip O'Keefe. *Materials & Methods,* Apr., 1953, p. 96.

Mathematics

Beiträge zur Numerischen Behandlung der Schrödinger-Gleichung im Falle des Yukawa-Potentials. Kalervo V. Laurikainen and Erkki K. Euranto. *ZAMP,* Mar. 3, 1953, p. 155. In German. On the instability of solutions of second order differential equations by the method of central differences.

Bounded-Weak Topologies and Completeness in Vector Spaces. G. T. Roberts. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 183.

A Class of Entire Functions Used in Analytic Interpolation. J. Berghuis. *Netherlands, Mathematisch Centrum, Amsterdam,* (Prelim.) Rep. R 143, 1952. 13 pp. (Also in *Proc. Royal Netherlands Acad. Sci., Amsterdam, Ser. A,* No. 5, 1952, p. 468.)

Computers, Statistics, and Mathematics. Arthur Rose, Joan A. Schilk, and R. Curtis Johnson. *Ind. & Eng. Chem.,* May, 1953, p. 933. 227 refs. Review of the literature.

Einschliessungssätze bei Iteration und Relaxation. L. Collatz. *ZAMM,* Feb.-Mar., 1952, p. 76. In German. Solution of the case of a system with n unknowns by iteration and relaxation methods; application to boundary problems connected with ordinary and partial differential equations.

Fredholm Solutions of Partial Integral Equations. Abdus Salam. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 213.

Der kanonische Formalismus in entarteten Fällen. Rudolf Haag. *ZAMM,* July, 1952, p. 197. In German. Formulation of "canonical formalism" for the case of the equation $\rho\alpha = \partial L/\partial \dot{q}\alpha$ that cannot be solved for the velocities $\dot{q}\alpha$; re-

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duction of the system and discussion of the relations between the Poisson brackets.

On the Method of Minimal Iterations. J. P. O. Silberstein. *Australia, ARL Rep. SM. 200,* Dec., 1952. 22 pp.

On the Product of *n* Linear Forms. H. Davenport. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 190.

On the Zeros of Polynomials and the Degree of Stability of Linear Systems. J. Frank Koenig. *J. Appl. Phys.,* Apr., 1953, p. 476.

Le Role de la Régularité dans le Calcul Numérique. (The Role of Regularity in Numerical Calculation.) Pierre Vernotte. *France, Min. de l'Air NT 45,* 1952. 33 pp. In French.

Séries de Fourier Régularité, Séries Divergentes et Formulation Expérimentale (Regularity in Fourier Series, Divergent Series and Experimental Formulation). Pierre Vernotte. *France, Min. de l'Air PST 259,* 1952. 105 pp. In French.

Solid Angle Subtended by a Circular Aperture at Point and Spread Sources: Formulae and Some Tables. Arthur H. Jaffey. *Argonne Natl. Lab. Rep. ANL-4875,* Sept., 1952. 29 pp.

Sur Quelques Problèmes Relatifs à l'Équation de Type Mixte de Tricomi (On Some Problems Relative to the Mixed-Type Equation of Tricomi). P. Germain and R. Bader. *France, ONERA Pub. 54,* 1952. 57 pp. In French.

Taylor-Entwicklungen und Finite Ausdrücke für Δu und $\Delta\Delta u$. J. Albrecht. *ZAMM,* Jan.-Feb., 1953, p. 41. In German. Clarification of the Taylor series expansion of a general statement that leads to finite-difference approximations of Δu and $\Delta\Delta u$; applications to regular grids of squares, triangles, hexagons, and cubes.

Über die Fehlerabschätzung beim Extrapolationsverfahren von Adams. II—Gleichungen Zweiter und Höherer Ordnung. P. Matthieu. *ZAMM,* Jan.-Feb., 1953, p. 26. In German. A method of estimating one error by Adams' extrapolation procedure extended to higher order equations.

Zur Auflösung Umfangreicher Linearer Gleichungssysteme. H. Unger. *ZAMM,* Jan., 1952, p. 1. In German. Method of solving extensive systems of linear equations in which the coefficient matrix is divided into submatrices.

Graphische Lösung von Gewöhnlichen Differentialgleichungen mit Nomographischen Hilfsmitteln. W. Richter. *ZAMM,* Apr.-May, 1952, p. 120. In German. A general method for the solution of certain first- or higher-order ordinary differential equations by use of nomograms.

On Nonlinear Elliptic Partial Differential Equations and Hölder Continuity. Louis Nirenberg. *Commun. on Pure & Appl. Math.,* Feb., 1953, p. 103. 21 refs.

On the Differential Equations for the Transition Probabilities of Markov Processes with Enumerably Many States. G. E. H. Reuter and W. Ledermann. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 247.

Résolution de Problèmes aux Limites au Moyen de Transformations Fonctionnelles. Paul Burgat. *ZAMP,* Mar. 3, 1953, p. 146. Method to obtain a type of series to solve boundary problems in which the homogenous corresponding problem is self-adjoint; application to problems of the second order and to partial differential equations.

Solution of Ordinary Linear Differential Equations with Variable Coefficients by Impulsive Admittances. W. J. Duncan. *Quart. J. Mech. & Appl. Math.,* Mar., 1953, p. 122.

Asymptotic Expansion of the Whittaker's Function $W_{k,m}(z)$ for Large Values of *k, m, z*. II. Chich-Chien Chang, Boa-Teh Chu, and Vivian O'Brien. *J. Franklin Inst.,* Apr., 1953, p. 319.

Fehlerabschätzung bei der Ersten Randwertaufgabe bei Elliptischen Differentialgleichungen. L. Collatz. *ZAMM,* July, 1952, p. 202. In German. For the first boundary value problem, use of the boundary maximum theorem for subharmonic functions in the estimation of the error of the approximate function.

Fonctions Biharmoniques Doublement Complexes et Applications aux Problèmes d'Élastostatique. Robert Legendre. *France, Min. de l'Air NT 42,* 1951. 45 pp. In French.

On Eigenvalues and Inverse Singular Values of Compact Linear Operators in Hilbert Space. J. P. O. Silberstein. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 201.

Ordinal Recursion. N. A. Routledge. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 175. A method of calculating functions of the positive integers which is related to Ackermann's transfinite recursion; application to any calculable function.

The Parseval Formulae for Monotonic Functions. IV. Sheila M. Edmonds. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 218.

Untersuchung einiger Integrale mit Bessel-Funktionen, die für die Elastizitättheorie von Bedeutung sind. Johannes Dörr. *ZAMP,* Mar. 3, 1953, p. 122. Investigations of some integrals with Bessel functions of importance in the theory of elasticity.

Use of Tschebyscheff-Polynomial Operators in the Numerical Solution of Boundary-Value Problems. George Shortley. *J. Appl. Phys.,* Apr., 1953, p. 392.

Eine Fehlerabschätzung für die Verfahren von Adams und Störmer. Johannes Weissinger. *ZAMM,* Feb.-Mar., 1952, p. 62. In German. Improvement of error estimations for the interpolation-extrapolation method of Adams and Störmer.

Maximalkorrelation und Korrelationsspektrum. Hans Gebelein. *ZAMM,* Jan., 1952, p. 9. In German. Analysis of maximum correlation theory and the correlation spectrum.

On Programs for Tests Involving Several Variables. O. Redlich and F. R. Watson. *Aero. Eng. Rev.,* June, 1953, p. 51. Development of a symmetric-squares method; application to the problem of the influence of cutting oils on cutting tools.

The Serial Test for Sampling Numbers and Other Tests for Randomness. I. J. Good. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 276.

Some Probability Limit Theorems with Statistical Applications. P. H. Diananda. *Proc. Cambridge Philos. Soc.,* Apr., 1953, p. 239.

Der Sonderschieber für Häufgkeitsrechnung. W. de Beauclair. *ZAMM,* Apr.-May, 1952, p. 112. In German. A new special slide rule for statistical computations.

Mechanics

Actes du Colloque International de Mécanique, Poitiers, 1950. I—Allocutions; Études sur Descartes; Mécanique Thermique. II, III—Étude sur la Mécanique des Fluides. IV—Études sur la Mécanique des Solides; Études sur la Mécanique Générale (Pt. 1). V—Études sur la Mécanique Générale (Pt. 2). *France, Min. de l'Air PST 248, 250, 251, 261, 263,* 1951, 1952. 298; 294; 335; 338; 263 pp. 652 refs. In French.

La Mécanique Rationelle dans un Espace à Quatre Dimensions et ses Applications. J. Loiseau. *France, Min. de l'Air PST 270,* 1952. 312 p. In French.

Sur une Généralisation de la Théorie Cinétique de Lindemann et Darmois–Sutra Concernant la Migration des Ions Electrolytiques Soumis à un Gradient de Potentiel (On the Generalization of the Kinetics Theory [of Mobility] of Lindemann and Darmois–Sutra Concerning the Migration of Electrolytic Ions Subjected to a Potential Gradient). Ilhami Civaoglu and Talât Erben. *Istanbul Tech. U. Bul.,* No. 1, 1951, p. 37. In French.

Meteorology

(Airborne) Radar Observations of Rain from Non-Freezing Clouds. R. S. Styles and F. W. Campbell. *Australian J. Phys.,* Mar., 1953, p. 73.

Cloud Visibility, Radar Reflectivity, and Drop-Size Distribution. David Atlas and Shepard Bartnoff. *J. Meteorology,* Apr., 1953, p. 143. USAF Cambridge Research Center studies.

A Method of Numerical Forecasting by Juxtaposition of One-Dimensional Solutions, and Its Application to the Equivalent Barotropic Model. W. Lawrence Gates. *J. Meteorology,* Apr., 1953, p. 149.

Numerical Integration of the Quasi-Geostrophic Equations for Barotropic and Simple Baroclinic Flows. J. G. Charney and N. A. Phillips. *J. Meteorology,* Apr., 1953, p. 71. 26 refs. USAF- and ONR-sponsored forecast problems research.

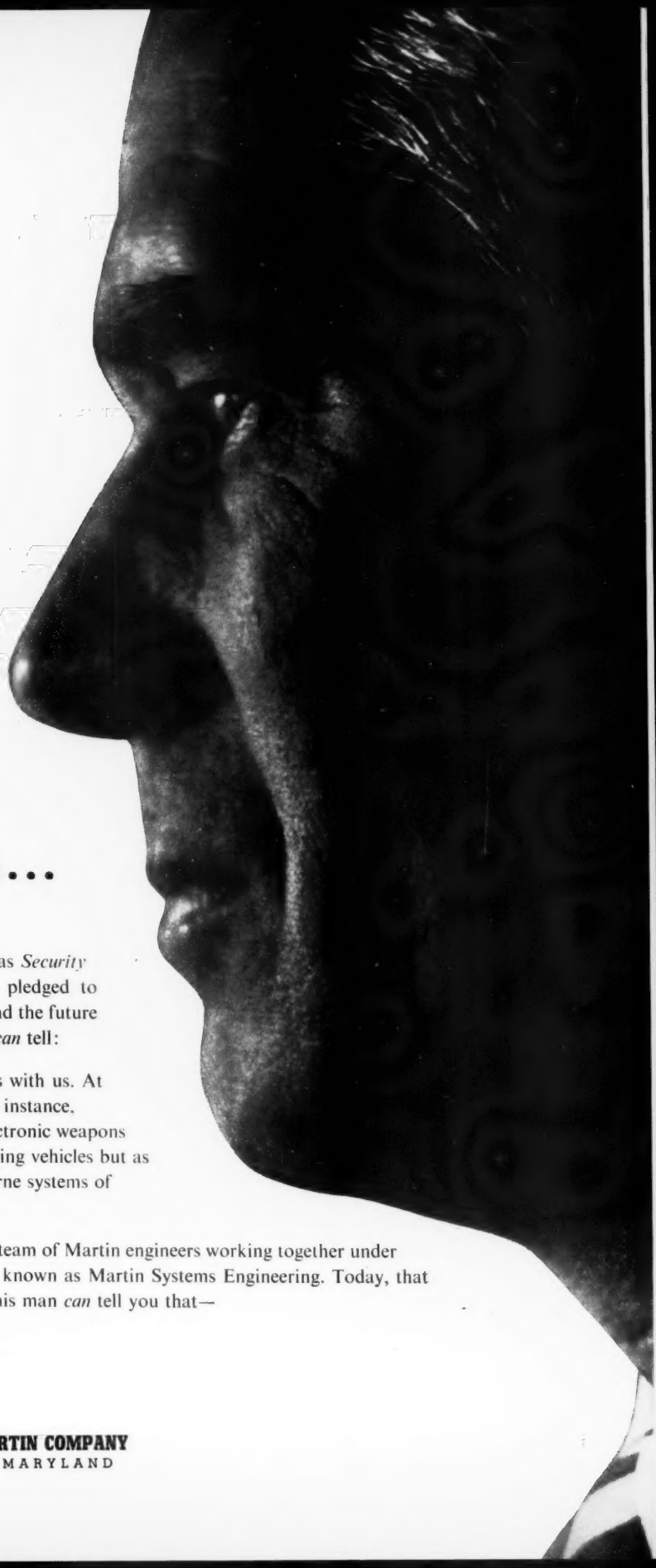
An Objective System for Estimating Fog and Stratus Probability at Randolph Field, Texas. Irving I. Gringorten. *Bul. AMS,* Feb., 1953, p. 63.

Relation of Gustiness to Other Meteorological Parameters. Irving A. Singer and Maynard E. Smith. *J. Meteorology,* Apr., 1953, p. 121. Brookhaven National Lab. wind turbulence control studies.

Some Thundercloud Electrification Studies. Seville Chapman. *Cornell Aero. Lab. Rep. CAL 47,* Oct., 1952. 41 pp. 30 refs.

Military Aviation

Engineering in Air Power. E. H. Heinemann. *Can. Av.,* May, 1953, p. 26. Aerodynamic, structural, electronic, metallurgical, thermodynamic, and other engineering aspects of military aviation.



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Dal Dirigible al Missile (From Airship to Missile). G. Arturo Crocco. *L'Aerotecnica*, Feb. 15, 1953, p. 6. In Italian.

The N.A.C.A.'s Role in Guided Missile Research. Joseph A. Shortal. (*SAE Annual Meeting, Detroit, Jan. 17, 1952, Paper.*) *Aircraft Eng.*, Apr., 1953, p. 96.

Recent Developments in Rockets and Guided Missiles in the United States. Norman J. Bowman. *J. Space Flight*, May, 1953, p. 20. Includes tabulated summary data on various research types.

USAF Missile Test Center Uses 1500-Mile Range for Flight Evaluation; Telemetered Data—as Many as 100 Functions—Recorded on Oscillographs for Complete Correlation. James B. Wynn, Jr., and Sam L. Ackerman. *CEC Recordings*, Apr., 1953, p. 3. At Patrick AFB, Fla.

The Zero-Lift Drag of a Slender Body of Revolution (NACA RM-10 Research Model) as Determined from Tests in Several Wind Tunnels and in Flight at Supersonic Speeds. Albert J. Evans. *U.S., NACA TN 2944*, Apr., 1953. 40 pp.

Navigation

The Vertical Reference in Aircraft. W. A. W. Fox and D. Barnett. *J. Inst. Navigation*, April, 1953, p. 161. Aircraft stability problems.

Photography

Aerotriangulation with the Kelsh Plotter. S. J. Friedman. *Photogrammetric Eng.*, Mar., 1953, p. 51.

Chronophotographie des Vibrations d'un Fluide. Joseph-Maurice Bourot. *France, Min. de l'Air PST 264*, 1952. 79 pp. In French.

High Speed Photography by Means of the Image Converter. J. A. Jenkins and R. A. Chippendale. *Philips Tech. Rev.*, Feb., 1953, p. 213.

Schlieren Method. Marjorie W. Evans. *The Frontier*, Mar., 1953, p. 6. Dynamics research applications.

Physics

The Diffraction of a Dipole Field by a Perfectly Conducting Half-Plane. T. B. A. Senior. *Quart. J. Mech. & Appl. Math.*, Mar., 1953, p. 101.

The External Magnetic Field of a Single Thick Semi-Infinite Parallel Plate Terminated by a Convex Semi-Circular Cylinder. N. Davy and N. H. Langton. *Quart. J. Mech. & Appl. Math.*, Mar., 1953, p. 115.

Generalized Magneto-Hydrodynamic Formulae. C. O. Hines. *Proc. Cambridge Philos. Soc.*, Apr., 1953, p. 299.

Mass Transfer. Robert L. Pigford. *Ind. & Eng. Chem.*, May, 1953, p. 957. 81 refs. Review of the literature.

Schlieren Optical Studies of the Critical Region of Pure Substances. Howard B. Palmer. *U. Wis. NRL Dept. Chem. Rep. CM-740*, Oct. 30, 1952. 239 pp. 77 refs. Studies on the critical regions of carbon dioxide, ethane, and xenon; pressure, liquid-vapor systems, thermodynamic, and other aspects.

Survey of the Equation of State and Transport Properties of Gases and Liquids. R. B. Bird, J. O. Hirschfelder, and C. F. Curtiss. *U. Wis. NRL Dept. Chem. Rep. CM-758*, Nov. 15, 1952. 73 pp. 101 refs.

Power Plants

The Birth of an Engine; British Practice in Aviation Engine Procurement and Development. F. R. Banks. *Aero. Eng. Rev.*, June, 1953, p. 31. (Also abridged in *The Aeroplane*, Apr. 24, 1953, p. 551.)

Les Moteurs d'Appoint. Jules Jarry. *Tech. et Sci. Aéronautiques*, No. 3, 1952, p. 139. In French. Power plants for auxiliary thrust—liquid and powder rockets, turbojets, pulse jets, afterburners, water injectors.

Possibilità del Turbogetto e dell'Autoreattore nel Campo Supersonico (On the Possibilities of Turbojets and Ram-Jets at Supersonic Speeds). Gaspare Santangelo. *L'Aerotecnica*, Feb. 15, 1953, p. 114. In Italian.

Jet & Turbine

Design and Development of a Broad-Range, High-Efficiency Centrifugal Compressor for a Small Gas-Turbine-Compressor Unit. Ivan E. Speer. *Trans. ASME*, Apr., 1953, p. 395.

Design Considerations and Development of a Broad Range, High Efficiency Centrifugal Compressor for a Small Gas Turbine Compressor. Ivan E. Speer. *ASME Semi-Annual Meeting, Cincinnati, June 15–19, 1952, Paper 52-SA-14.* 22 pp.

Some Investigations with Wet Compression. J. T. Hamrick and W. L. Beede. *ASME Semi-Annual Meeting, Cincinnati, June 15–19, 1952, Paper 52-SA-15.* 26 pp. (Also in *Trans. ASME*, Apr., 1953, p. 409.) Experiments on centrifugal-flow compressors using water injection.

Le Développement du T.R. 300 par Hispano Suiza (Development of the Hispano Suiza 300 Turbojet). Jacques Blanc. *Tech. et Sci. Aéronautiques*, No. 3, 1952, p. 175. In French.

Differences in the Design and Operation of Military and Commercial Transport Turbine Engines. R. T. Holland. *SAE Annual Meeting, Detroit, Jan. 12–16, 1953, Preprint 33.* 8 pp.

Moteurs Complexes et Mototurbine; Application à la Propulsion des Avions (Complex Engines and the Turbine Power Plant; Application to the Propulsion of Aircraft). I, II—Tableaux. III—Diagrammes. Maurice Roy and R. Le Bont. *France, ONERA Pub. 50*, 1952. 126; 84; 174 pp. In French.

Optimum Controllers for Linear Closed-Loop Systems. Aaron S. Boksenbom, David Novik, and Herbert Heppler, *U.S., NACA TN 2939*, Apr., 1953. 27 pp.

Problèmes Posés par la Fabrication du Turbo-Réacteur Nene (Problems in the Production of the Nene Turbojet). Jacques Blanc. *Tech. et Sci. Aéronautiques*, No. 3, 1952, p. 164. In French.

A Rapid Method for Use in Design of Turbines Within Specified Aerodynamic Limits. Richard H. Cavicchi and Robert E. English. *U.S., NACA TN 2905*, Apr., 1953. 72 pp., folded charts. Application of basic thermodynamic relations for the determination of velocity diagrams.

Variazione delle Grandezze Caratteristiche di un Turboreattore in Funzione delle Condizioni di Funzionamento (Analysis of the Performance Characteristics of the Turbojet Engine as a Function of Operation Conditions). Ludovico Pascucci. *L'Aerotecnica*, Feb. 15, 1953, p. 94. In Italian.

Reciprocating

Combustion Chamber Deposits in Reciprocating Aero Engines. A. R. Griffin. *J. SLAE*, Feb., 1953, p. 3.

Pressure Pulsation at the Intake of a Supercharged Internal-Combustion Engine. L. S. Dzung. *Brown Boveri Rev.*, Aug.-Sept., 1952, p. 295.

The "Nomad" Compounded Diesel Engine. *The Engr.*, Mar. 20, 1953, p. 422.

Rocket

Combustion Instability in an Acid-Heptane Rocket with a Pressurized-Gas Propellant Pumping System. Adelbert O. Tischler and Donald R. Bellman. *U.S., NACA TN 2936*, May, 1953. 50 pp.

Zur Bestimmung des optimalen Brennkammerdruckes von Raketen-Triebwerken. H. H. Kölle. *Weltraumfahrt*, Jan., 1953, p. 9. In German. Determination of the optimum combustion-chamber pressure in a rocket motor.

Instrumentation for Rocket Testing. Edward Cartotto. *Instruments, J. Southern Calif. Meter Assn.* Sect., Apr., 1953, p. 585.

Problemi Tipici Nel Progetto di Missili a Propellenti Liquidi (Typical Problems in Design of Liquid Propellant Rockets.) Vittorio Sivori. *L'Aerotecnica*, Feb. 15, 1953, p. 118. In Italian.

Production

The Canadian Aeronautical Scene. F. T. Meacock. *The Aeroplane*, Apr. 17, 1953, p. 483, cutaway drawings. Forty-four-page resources and production survey of the industry and the RCAF.

Glasscloth-Moulding. I—Manufacture of the Radome for the Avro Shackleton; Use of Low-Density Core Material. Richard Wood. *Aircraft Prod.*, Apr., 1953, p. 146.

Theory of Extrusion; A Symposium at ACS 122nd Meeting, Atlantic City, N. J. I—Basic Concepts of Extrusion. J. F. Carley and R. A. Strub. **II—Simplified Flow Theory for Screw Extruders.** J. F. Carley, R. S. Mallouk, and J. M. McKelvey. **III—Application of Theory to Design of Screw Extruders.** J. F. Carley and R. A. Strub. **IV—Experimental Studies of Melt Extrusion.** J. M. McKelvey. **V—Power Requirements of Melt Extruders.** R. S. Mallouk and J. M. McKelvey. **VI—Extruder Scale-Up Theory and Experiments.** J. F. Carley and J. M. McKelvey. **VII—Future Extrusion Studies.** C. H. Jepson. *Ind. & Eng. Chem.*, May, 1953, pp. 969; 974; 978; 982; 987; 989; 992. 33 refs.

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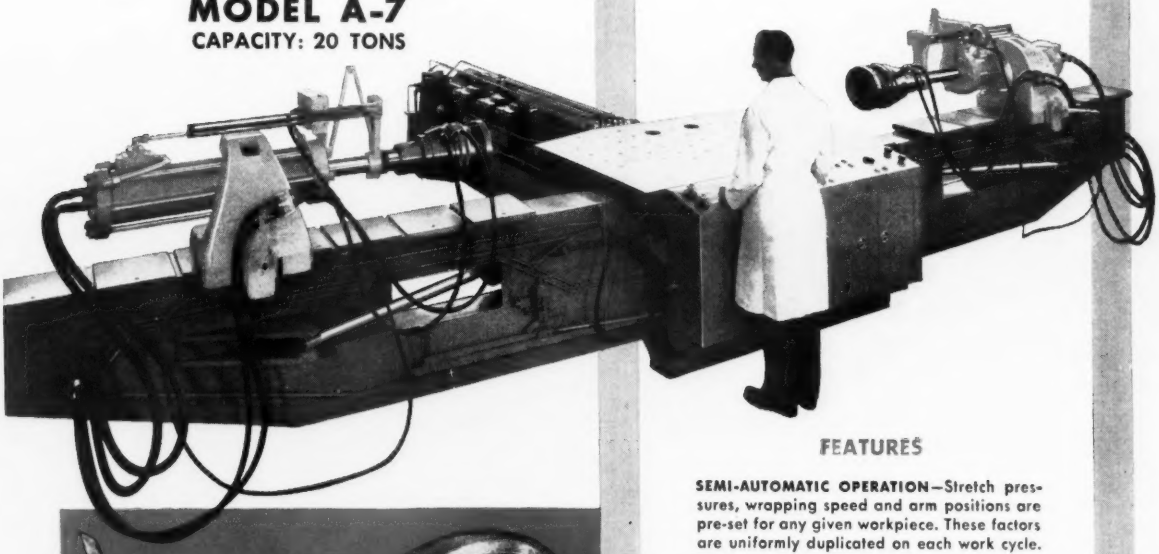

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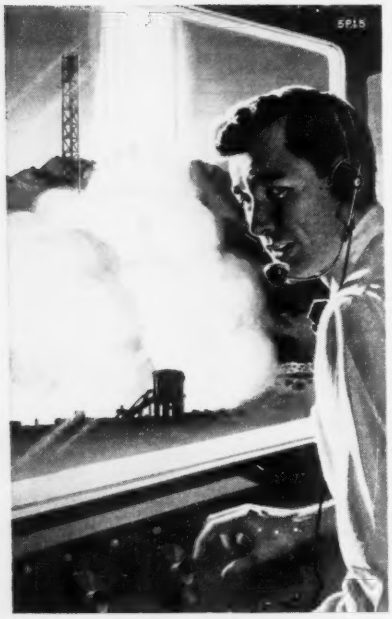

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Automation of Machine Tools. I—Principles of Control. II—Control Applications. Julius Y. Kaplan. *Tool Engr.*, Apr., May, 1953, pp. 53; 50. USAF development; application of servomechanisms to aircraft and other parts.

Greater Automaticity in Tooling for (G-E) J-47 Turbojet Engines. Thomas MacNew. *Auto. Ind.*, May 1, 1953, p. 68.

Metalworking

Deformation Work Absorbed by the Work-piece During Metal Cutting. E. G. Thomsen, J. T. Lapsley, Jr., and R. C. Grassi. *Trans. ASME*, May 1953, p. 591. 20 refs.

Large Spun Metal Shapes. W. A. Wenman. *Materials & Methods*, Apr., 1953, p. 93. Advantages and applications of spinning.

Some Observations on Chip Curl in the Metal-Cutting Process Under Orthogonal Cutting Conditions. R. S. Hahn. *Trans. ASME*, May, 1953, p. 581. 20 refs.

Unitized Designs Are Replacing Built-Up Assemblies. Charles F. Marschner. *Prod. Eng.*, May, 1953, p. 199. Extrusion and machining methods to produce large structural elements.

Bonding Rubber to Metal; Design and Production Problems. J. H. Gerstemaier. *Tool Engr.*, May, 1953, p. 59. Application to manufacture of aluminum mounts and other aircraft components.

Continuous Casting of Metals. I—Introduction. A. J. Murphy. **II—Metallurgical and Engineering Problems.** V. Kondic. **III—Continuous Casting of Non-Ferrous Metals.** J. Crowther. *Metal Treatment*, Apr., 1953, p. 171.

Design Tips for Changing to Die Casting. H. K. Barton. *Prod. Eng.*, Apr., 1953, p. 174.

Investment Castings: They're Getting Bigger. J. R. Burns. *Prod. Eng.*, Apr., 1953, p. 137. Gas-turbine engine and other applications.

Large Forging-Presses; A Review of Their Potentialities and a Consideration of Important Factors in Die-Forging. G. W. Richards. *Aircraft Prod.*, May, 1953, p. 154.

Rotary Forming; Complex Contours by Stretching, Compression or Combined Stretching and Compression. I—Machine Construction and Methods of Operation. II—Sheet Forming; Die Manufacture; Wiping Die-Sections into Position on the Rotary Table; Equipment. *Aircraft Prod.*, Apr., May, 1953, pp. 118; 175.

Stretch-Forming. III—Tooling Methods; Die Materials; The Construction and Use of Matched Tools; Support-Snakes; Heat-Treatment. *Aircraft Prod.*, May, 1953, p. 169.

Jet Engine Parts Produced in Record Time. John W. Greve. *Tool Engr.*, May, 1953, p. 63. G-E J47 jet program.

Scroll-Milling; Machining a Variable-Lead and Variable Core-Diameter Helical Form. H. J. Pearson. *Aircraft Prod.*, May, 1953, p. 162.

Pop Rivet Fasteners for Aircraft. G. C. Bailey and P. C. Ergler. *Prod. Eng.*, May, 1953, p. 191. Structural design and cost factors; static and fatigue tests on pop-riveted joints.

Control of Penetration and Melting Ratio with Welding Technique. Clarence E. Jackson and Arthur E. Shrubsall. *Welding J., Res. Suppl.*, Apr., 1953, p. 172-s.

Designing Around Inert-Gas Metal Arc Welded Stainless, Nickel and Stainless Clads, Copper, Copper Base Alloys, Aluminum. J. H. Berryman. *Prod. Eng.*, Apr., 1953, p. 171.

Gas Flow Requirements for Inert-Gas-Shielded Arc Welding. Glenn J. Gibson. *Welding J., Res. Suppl.*, Apr., 1953, p. 198-s.

The Inert-Gas-Shielded Metal-Arc Welding Process. I. W. H. Wooding. *Welding J.*, Apr., 1953, p. 299.

Materials & Methods Manual No. 94: Welding the Stainless Steels. Helmut Thielsch. *Materials & Methods*, May, 1953, p. 115. Welding requirements for austenitic, martensitic, and ferritic grades; recommended procedures and joint designs.

The Semiautomatic Inert-Gas Metal-Arc Welding of Aluminum Alloys. Charles T. Gayley, Joseph R. Girini, and Walter H. Wooding. *Welding J., Res. Suppl.*, Apr., 1953, p. 179-s.

The Welding of Thick Plates of High-Strength Aluminum Alloys. D. C. Martin, M. I. Jacobson, and C. B. Voldrich. *Welding J., Res. Suppl.*, Apr., 1953, p. 161-s.

Production Engineering

Determining Moments of Inertia of Nonsymmetrical Components. William E. Soong. *Mach. Des.*, May, 1953, p. 181. Application to servomechanisms and high-speed oscillating mechanisms.

How Materials Engineering Works at Northrop. Charles M. Miller. *Materials & Methods*, Apr., 1953, p. 83.

A 150-kV X-Ray Equipment for the Radiography of Circumferential Welds in Gas-Turbine Rotors. F. W. Waterton. *Proc. IEE, Part II (Paper 1379)*, Apr., 1953, p. 105; **Discussion**, p. 112.

Quality Control Methods; Their Use in Design. X—Operations Research. Dorian Shainin. *Mach. Des.*, May, 1953, p. 176.

Propellers

CdS Detector Checks Propeller Thickness. John F. Howell. *Electronics*, May, 1953, p. 159. Cadmium-sulfide x-ray equipment for measuring wall thickness of blades.

Circulation Distribution for Six- and Eight-Bladed Propellers. Y. V. G. Acharya. *Appl. Sci. Res., Sect. A.*, No. 6, 1953, p. 410.

Contribution à l'Étude Aérodynamique de l'Aile et de l'Hélice. Maurice Ménard. *France, Min. de l'Air PST 262*, 1952. 187 pp. In French. Experimental studies on the aerodynamic characteristics of wings and propeller blades.

Propeller Reversing Problems. David L. Posner. *Aero. Eng. Rev.*, June, 1953, p. 44.

A Simple Thrust Indicator for Propeller-Driven Airplanes. A. W. Vogeley and M. N. Gough. *Aero. Eng. Rev.*, June, 1953, p. 47.

Reference Works

Chemical Engineering Fundamentals. *Ind. & Eng. Chem.*, May, 1953, p. 891. 2329 refs. Review of the literature covering research in: various chemical rate processes; computers, statistics, and mathematics; colloidal and surface phenomena; fluid dynamics; heat and mass transfer; and thermodynamics.

A Dictionary of Metallurgy. XV—FOGA. A. D. Merriman and J. S. Bowden. *Metal Treatment*, Apr., 1953, p. 163.

Reports of Research in the Field of Engineering Psychology. Julien M. Christensen and Harry R. Collins. *USAF TR 53-75*, Apr. 1, 1953. 25 pp. 198 refs. A bibliography of functionally grouped reports published by the WADC Psychology Branch, Aero Medical Lab., Directorate of Research, since its inception in 1945.

25th Annual Directory Issue. *Western Av.*, Apr., 1953. 114 pp. Includes engineering specifications on military, transport, cargo, and utility aircraft, helicopters, convertiplanes, and power plants.

Rotating Wing Aircraft

An Introduction to the Helicopter. J. D. Sibley. *J. RAeS.*, Apr., 1953, p. 228. General performance; control and stability; rotor vibration problems.

Nouvelles Applications du Principe de Gyrodyne (New Applications of the Gyrodyne Principle). J. A. J. Bennet. *Tech. et Sci. Aéronautiques*, No. 1, 1952, p. 37. In French.

Transition Automatique du Vol Stationnaire des Hélicoptères en Autorotation Verticale et en Atterrissage Moteur Coupé (Automatic Transition of Stationary Flight of Helicopters in Vertical Autorotation and in Landing with the Engine Shut Off). J. Meijer Drees. *Tech. et Sci. Aéronautiques*, No. 1, 1952, p. 14. In French.

Helicopter Landing Gear; Some Problems the Designer Must Face. Maurice F. Allward. *Flight*, Apr. 3, 1953, p. 427.

Matching the Characteristics of Helicopters and Shaft Turbines. D. N. Meyers and Z. M. Ciolkosz. *SAE Annual Meeting, Detroit, Jan. 12–16, 1953, Preprint 19.* 22 pp.

Attache par Faisceaux de Lames Élastiques des Pales d'Appareils à Voilures Tournantes (Attachment by a Number of Elastic Plates of the Blades of Rotary-Wing Machines). Théodore Laufer. *Tech. et Sci. Aéronautiques*, No. 1, 1952, p. 39. In French.

The Contribution of Higher Mode Resonance to Helicopter Rotor-Blade Bending. Harold Hirsch. *J. Aero. Sci.*, June, 1953, p. 407.

Discussion of Rotor Systems. I—The Hinged-Blade Lifting Rotor. R. L. Lichten. **II—The Bell Rotor System.** Frank M. Anthony. *AHS, Southwestern Reg. Meeting, Grand Prairie, Tex., Oct. 1, 1952, Paper.* 11 pp.

Étude de Transport par Hélicoptères. Paul Codos. *Tech. et Sci. Aéronautiques*, No. 1, 1952, p. 4. In French. A study of the transport use of helicopters.

L'Exploitation des Hélicoptères dans les Sondages Atmosphériques (Operation of Helicopters in Atmospheric Observations). L. Santomauro. *Tech. et Sci.*

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Aéronautiques, No. 1, 1952, p. 54. In French.

Space Travel

Die Bewegung einer Aussenstation in einer elliptischen, zum Erdäquator geneigten Bahn um die Erde. I. Helmut Krause. *Weltraumfahrt*, Jan., 1952, p. 17. Motion of a space station around the earth in an elliptic path tilted with respect to the earth's equator.

Chemische Probleme des Weltraumfluges (Chemical Problems of Space Flight). Friedrich Hecht. *Weltraumfahrt*, Jan., 1953, p. 3. 29 refs.

Four Steps to the Moon. Kenneth Jacobs. *The Frontier*, Mar., 1953, p. 10. Four-stage rocket propulsion requirements.

Möglichkeiten des Überganges aus einer Ellipsenbahn in eine Kreisbahn und umgekehrt. II. Werner Schaub. *Weltraumfahrt*, Oct., 1952, p. 106. Possibilities of the transition from an elliptical orbit to a circular orbit and vice versa.

Navigational Calculations in Space Flight (Investigation of the Effect of the Precision of Astronomical Data). I—Planetary Orbital Distances. *J. Space Flight*, Apr., 1953, p. 1.

Structures

Evaluation of Stresses in a Circular Ring by the Relaxation Method. Y. V. G. Acharya. *Appl. Sci. Res., Sect. A.*, No. 6, 1953, p. 415.

Flexure with Shear Centres: A General Treatment with Complex Variable. R. Capildeo. *Proc. Cambridge Philos. Soc.*, Apr., 1953, p. 308.

Integral Construction; Its Application to Aircraft Design and its Effect on Production Methods. E. D. Keen. *J. RAeS.*, Apr., 1953, p. 215. (Also in *Aircraft Prod.*, Apr., May, 1953, pp. 134; 172.)

Interim Report on a Fatigue Investigation of a Full-Scale Transport Aircraft Wing Structure. M. James McGuigan, Jr. *U.S., NACA TN 2920*, Apr., 1953. 36 pp.

Linear Elastic Stability; A Critical Analysis of Methods. Hans Ziegler. *Z.AMP*, Mar. 15, 1953, p. 89. 42 refs.

A Method of Obtaining Shear Stress-Strain Graphs by Interpretation of Moment-Twist Data. P. H. Kaar. *Trans. ASME*, May, 1953, p. 521.

A New Test Rig for Static Tests on Structures and Components. F. Mueller-Magyari. (*Maschinenbau und Wärmewirtschaft*, Jan., 1953, p. 1.) *Engr. Dig.*, Apr., 1953, p. 116.

Regolamento e Norme Sulle Strutture Degli Aeroplani (Requirements and Rules on the Aeroplane Structures). Lucio Lazzarino. *L'Aerotecnica*, Feb. 15, 1953, p. 87. In Italian.

Shear Center of Semi Elliptical Cross Section. Mustafa Inan. *Istanbul Tech. U. Bul.*, No. 1, 1951, p. 25.

Sulla Rigidezza delle Strutture ed Elementi Sovrabbondanti (On the Rigidity of Redundant Structures). Carlo Riparbelli. *L'Aerotecnica*, Feb. 15, 1953, p. 106. In Italian.

Über den Parametereinfluss auf einfache Nichtstationäre Bewegungen. W. Bader. *ZAMM*, Oct., 1952, p. 297. In German. Angles of Euler and the vector of celerity as dependent variables in the linearized equations of movement of a rigid body in a resistant medium.

Bars & Rods

Étude d'Équations aux Dérivées Partielles Rencontrées dans la Théorie des Phénomènes de Torsion. Pierre Brousse. *France, Min. de l'Air PST 257*, 1952. 76 pp. In French. Study of torsion of a shaft of revolution.

Generalisation of the Conjugate Beam Method to Space Rods. Bekir Tekinalp. *Istanbul Tech. U. Bul.*, No. 1, 1951, p. 29.

On the Plastic Distortion of Solid Bars by Combined Bending and Twisting. R. Hill and M. P. L. Siebel. *J. Mech. & Phys. Solids*, Apr., 1953, p. 207.

Beams & Columns

Analysis of Two-Cell Swept Box with Ribs Parallel to the Line of Flight under Loading by Constant Couples. D. Howe. *Coll. of Aeronautics, Cranfield, Rep. 64.* 13 pp.

The Centre of Shear of Aerofoil Sections. John A. Jacobs. *J RAeS.*, Apr., 1953, p. 235.

Flange Buckling in a Bent I-Section Beam. J. F. Davidson. *J. Mech. & Phys. Solids*, Apr., 1953, p. 149.

Cylinders & Shells

The Combined Bending and Twisting of Thin Cylinders in the Plastic Range. M. P. L. Siebel. *J. Mech. & Phys. Solids*, Apr., 1953, p. 189.

Contribution à l'Étude des Contraintes dans les Pièces Cylindriques Soumises à la Torsion (Contribution to the Study of Stress in Cylinders Subjected to Torsion). C. L. Schwartz. *Tech. et Sci. Aéronautiques*, No. 3, 1952, p. 181. In French.

Critical Buckling Shear Stresses in Thin Cylinders. J. J. Eden. *Prod. Eng.*, Apr., 1953, p. 225.

Influence of Residual Stress on Behavior of Thick-Wall Closed-End Cylinders. J. H. Faupel and A. R. Furbeck. *Trans. ASME*, Apr., 1953, p. 345.

Kugel mit Normalgerichteten Einzelkräften. C. Weber. *ZAMM*, June, 1952, p. 186. In German. Stress investigation of the case of two forces at the poles of a sphere with a normally directed single or point load concentration.

The Stress Distribution in the Head of a Thin-Walled Pressure Vessel. H. B. Fergusson, J. Kudar, and R. B. Harvey. *Quart. J. Mech. & Appl. Math.*, Mar., 1953, p. 1.

Plates

Beiträge zur Theorie der Achsensymmetrisch Belasteten Schweren Dicken Kreisplatte. István Szabó. *ZAMM*, Nov.-Dec., 1952, p. 359. In German. Theoretical investigation of the problem of the thick circular plate with axially symmetric load.

Buckling of Oblique Plates with Clamped Edges under Uniform Compression. W. H. Wittrick. *Aero. Quart.*, Feb., 1953, p. 151.

Die in Achsenrichtung Rotationssymmetrisch Belastete Dicke Kreisplatte auf Nachgiebiger und auf Starrer Unterlage. István Szabó. *ZAMM*, Apr.-May, 1953, p. 145. In German. Investigation into the problem of the thick circular plate under rotationally-symmetrical strain acting in axial direction and extended to the case of the plate bedded elastically or rigidly.

Ein Beitrag zur Statik der Kreisplatten. H. Jung. *ZAMM*, Feb.-Mar., 1952, p. 46. In German. Use of the Hankel transformation to determine deflections of circular plates under rotationally symmetrical strain and to measure pressure distribution under elastically bedded circular plates.

The Green's Function of an Elastic Plate. W. R. Dean. *Proc. Cambridge Philos. Soc.*, Apr., 1953, p. 319.

Some Notes on the Mathematical Theory of a Loaded Elastic Plate Resting on an Elastic Foundation. R. K. Livesley. *Quart. J. Mech. & Appl. Math.*, Mar., 1953, p. 32.

Stress Analysis of Sheet-Stringer Panels with Cutouts. Harvey G. McComb, Jr. *J. Aero. Sci.*, June, 1953, p. 387.

Stresses and Deflection in a Flat Plate with Clamped Edges under Normal Pressure. J. K. Oaks. *J.RAeS.*, Apr., 1953, p. 244.

Theorie der Druckstabilität der Sandwichplatte. I, II. H. Neuber. *ZAMM*, Nov.-Dec., 1952, Jan.-Feb., 1953, pp. 325; 10. In German. Integration of the basic equations of elastic stability for sandwich plates; technical applications; diagrams for optimum thickness ratio.

Über eine Verfeinerung der Klassischen Theorie Dünner Schwach Gebogener Platten. Manfred Schäfer. *ZAMM*, June, 1952, p. 161. In German. Method for deducing the fundamental equations of the bending of plates which permits three boundary conditions to be satisfied; application to a rectangular plate with variable load and free boundaries.

Thermodynamics

Actes du Colloque International de Mécanique, Poitiers, 1950. I—Allocutions; Études sur Descartes; Mécanique Thermique. *France, Min. de l'Air PST 248*, 1951. 298 pp. 174 refs. In French. Problems of energy and propulsion; heat exchange and other factors.

Aerothermodynamics and Combustion Theory. Theodore von Kármán. *L'Aerotecnica*, Feb. 15, 1953, p. 80. Problems of flame propagation, detonation and deflagration, and flamefront as flow discontinuity.

Les Aspects Fondamentaux de la Thermocinétique (Fundamental Aspects of Thermokinetics). I—Theory. II—Measurements. Pierre Vernotte. *France, Min. de l'Air NT 41, 43*, 1951. 45; 54 pp. In French.

Constantes Thermodynamiques des Gaz aux Températures Élevées (Thermodynamic Constants of Gases at High Temperatures). M. G. Ribaud. *France, Min. de l'Air PST 266*, 1952. 169 pp. In French.

Temperature Effects in Aeronautics. W. F. Hilton. *The Aeroplane*, Apr. 10, 1953, p. 462.

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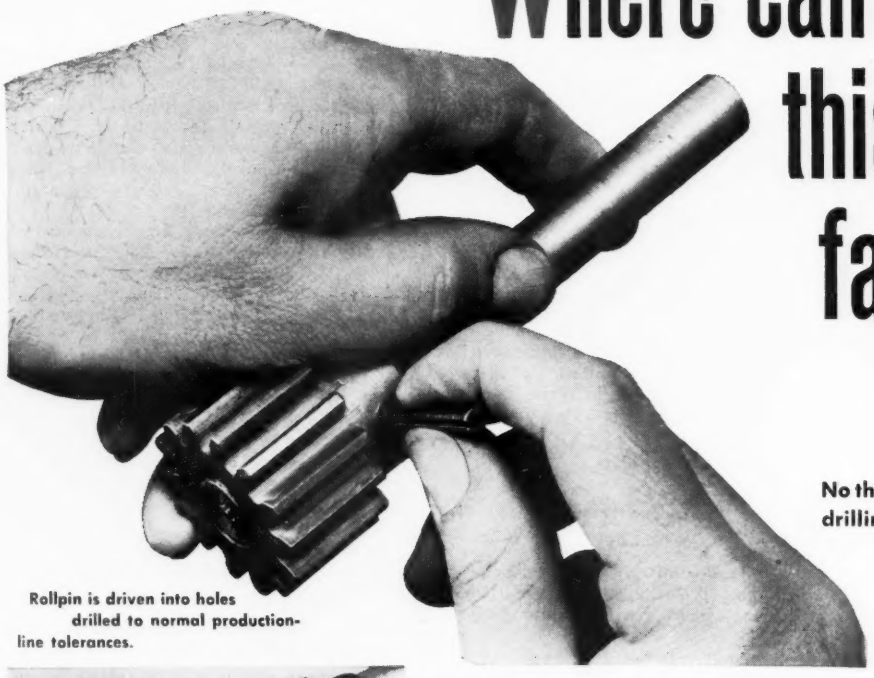

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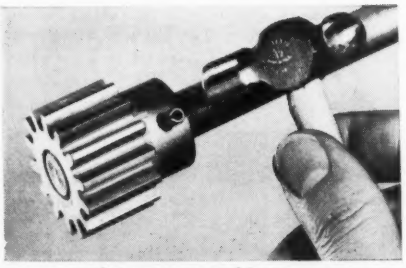

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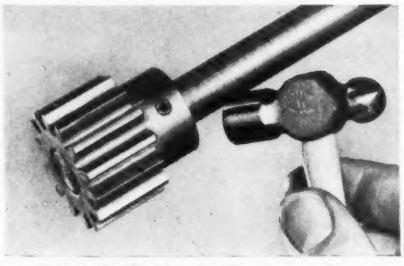

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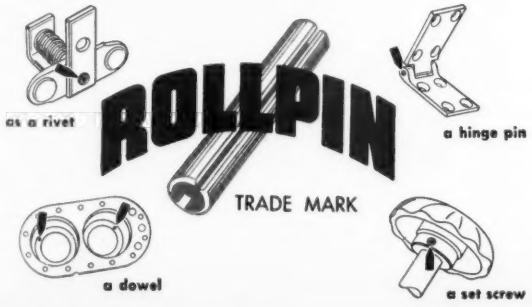

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The Theory of Flame Propagation. IV. J. O. Hirschfelder, C. F. Curtiss, and Dorothy E. Campbell. *U. Wis. NRL Dept. Chem. Rep. CM-756*, Nov. 24, 1952. 50 pp. 20 refs.

Thermodynamics. J. M. Smith. *Ind. & Eng. Chem.*, May, 1953, p. 963. 215 refs. Review of the literature.

Heat Transfer

Application de la Notion d'Échauffement Relatif à l'Étude de la Convection Forcée de la Chaleur. Edouard Roche. *France, Min. de l'Air PST 267*, 1952. 78 pp. In French. Studies on heat transfer and related problems.

Heat Transfer. E. R. G. Eckert. *Ind. & Eng. Chem.*, May, 1953, p. 951. 182 refs. Review of the literature.

Local Coefficients of Mass Transfer by Evaporation of Water Into an Air Jet. Maurice Spielman and Max Jakob. *Trans. ASME*, Apr., 1953, p. 385.

The Relation Between the Heat Transfer and the Convection Phenomena in Enclosed Plane Air Layers. J. G. A. de Graaf and E. F. M. van der Held. *Appl. Sci. Res., Sect. A.*, No. 6, 1953, p. 393.

Thermal Conductivity of Binary Gas Mixtures at Atmospheric Pressure. John M. Lenoir. *U. Ark. Engr. Exp. Sta. Bul. 16*, Oct., 1952. 26 pp. 23 refs.

Water-Borne Aircraft

L'Avenir de l'Hydravion (The Future of the Seaplane). Henry Knowler. *Tech. et Sci. Aéronautiques*, No. 2, 1952, p. 74. In French. Survey of technical developments, with charts and diagrams.

Estimation of Hydrodynamic Impact Loads and Pressure Distributions on Bodies Approximating Elliptical Cylinders with Special Reference to Water Landings of Helicopters. Emanual Schnitzer and Melvin E. Hathaway. *U.S., NACA TN 2889*, Apr., 1953. 31 pp.

Wind Tunnels & Research Facilities

An Electrolytic Tank Developed for Obtaining Velocity and Pressure Distributions About Hydrodynamic Forms. A. Borden, G. L. Shelton, Jr., and W. E. Ball, Jr. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 824*, Apr., 1953. 35 pp.

Les Principes Physiques de la Formulation de Lois Expérimentales; Conséquences pour la Philosophie de Sciences; Calcul Effectif de Différents Types de Lois. Pierre Vernotte. *France, Min. de l'Air PST 271*, 1952. 288 pp. In French. The physical principles in the formulation of experimental laws; consequences for research and scientific philosophy; effective calculation of different types of laws.

Research Review. Joseph Black. *Aeronautics*, Apr., May, 1953, pp. 38; 30. Survey of problems of noise reduction, boundary-layer control, structural fatigue, wing proportions and materials, and gas turbine applications.

Étude d'un Champ Aérodynamique par les Ultrasons Combinés à la Strioscopie. M. Merle. *France, Min. de l'Air NT 44*, 1951. 28 pp. In French. Visualization of flow by the use of a striation method and ultrasonic sound waves.

Horsepower Requirements of Supersonic Wind Tunnels. H. Luskin and Martha E. Graham. *Douglas Rep. SM 13365*, Sept. 10, 1948. 19 pp.

A Note on the Theory of the Constant-Area Mixing of Compressible Flows as Applied to High-Speed Wind Tunnel Design. F. G. Irving. *Aero. Quart.*, Feb., 1953, p. 164.

The Upwash Correction for an Oscillating Wing in a Wind Tunnel. Theodore R. Goodman. *J. Aero. Sci.*, June, 1953, p. 383.

The Zero-Lift Drag of a Slender Body of Revolution (NACA RM-10 Research Model) as Determined from Tests in Several Wind Tunnels and in Flight at Supersonic Speeds. Albert J. Evans. *U.S., NACA TN 2944*, Apr., 1953. 40 pp.

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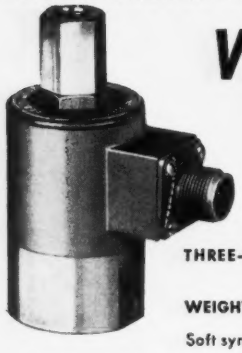

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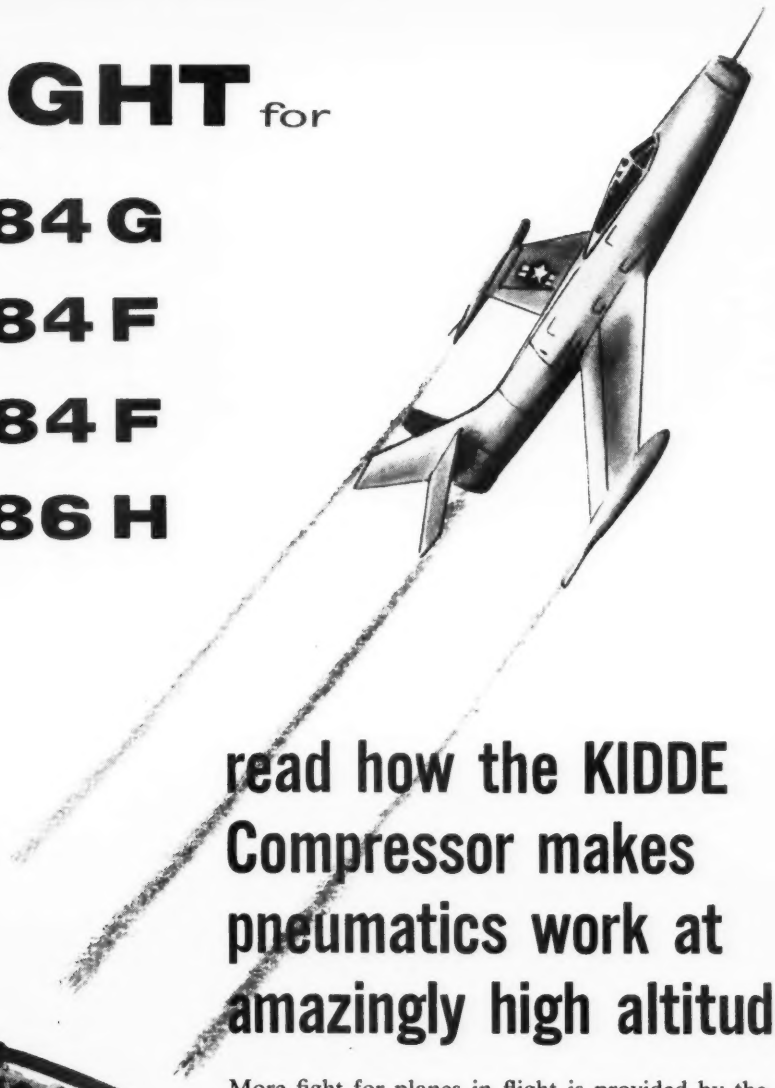

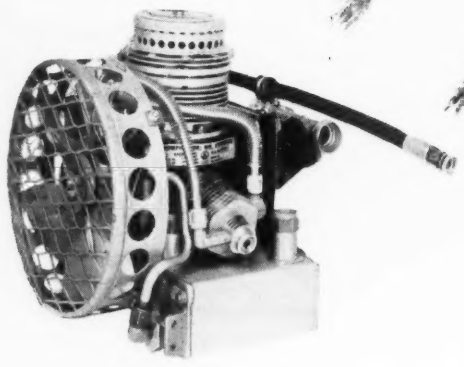

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This "repackaging" of Avien's capacitance-type fuel gage is 50% lighter and needs no field adjusting

Ever since Avien developed its capacitance-type fuel gage, our engineers have stuck to the task of reducing the system to its simplest form.

Now they've done it, with the Avien Two-Unit Fuel Gage.

Basically, it is the same sharply accurate system that Avien has designed and which has been installed on thousands of modern planes. The big news is in the "package"—for the necessary components have been reduced to a sensing unit and an indicating unit.

Avien has buried the "black box"

Up until now, most fuel gaging systems needed four units; a tank unit, an indicator, a bridge-amplifier, and a shock-mount to guard it against vibration.

No field calibration was required for the Avien tank unit or indicator. Avien held them to such close tolerances, the adjustments for individual installations were actually "built in."

The bridge-amplifier (the "black box") was a different story. This intermediate unit was supplied as a common part, for universal application. And that's where field calibration *had* to be made.

The rigid specs for the bridge-amplifier component have previously held back improvements in the system as to weight, size, cost, performance and flexibility. There was only one answer, as far as Avien was concerned. The "black box" had to go.

In the Avien Two-Unit system, the necessary components for the bridge and amplifier functions have been built into the indicator case. The "black box" is eliminated, and so are certain components which were necessary to make the "black box" universally applicable.

No more field adjustments

The Two-Unit Fuel Gage gets installation down to "plug-in, plug-out" simplicity.

The Avien tank unit and indicator are pre-calibrated for the aircraft they are designed for. Since the intermediate unit is not needed, neither is field calibration.

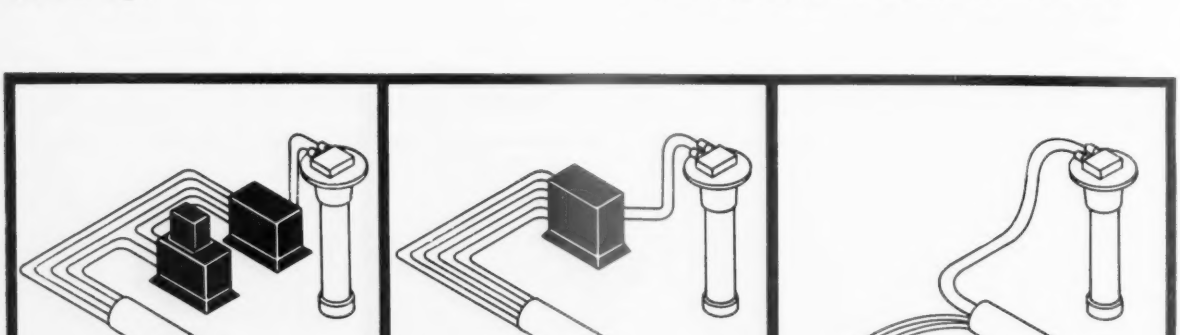
Since no calibration is required, all units designed for the same aircraft are interchangeable. Avien units are now all "shelf items."

The Two-Unit Gage eliminates three drawbacks of field calibration:

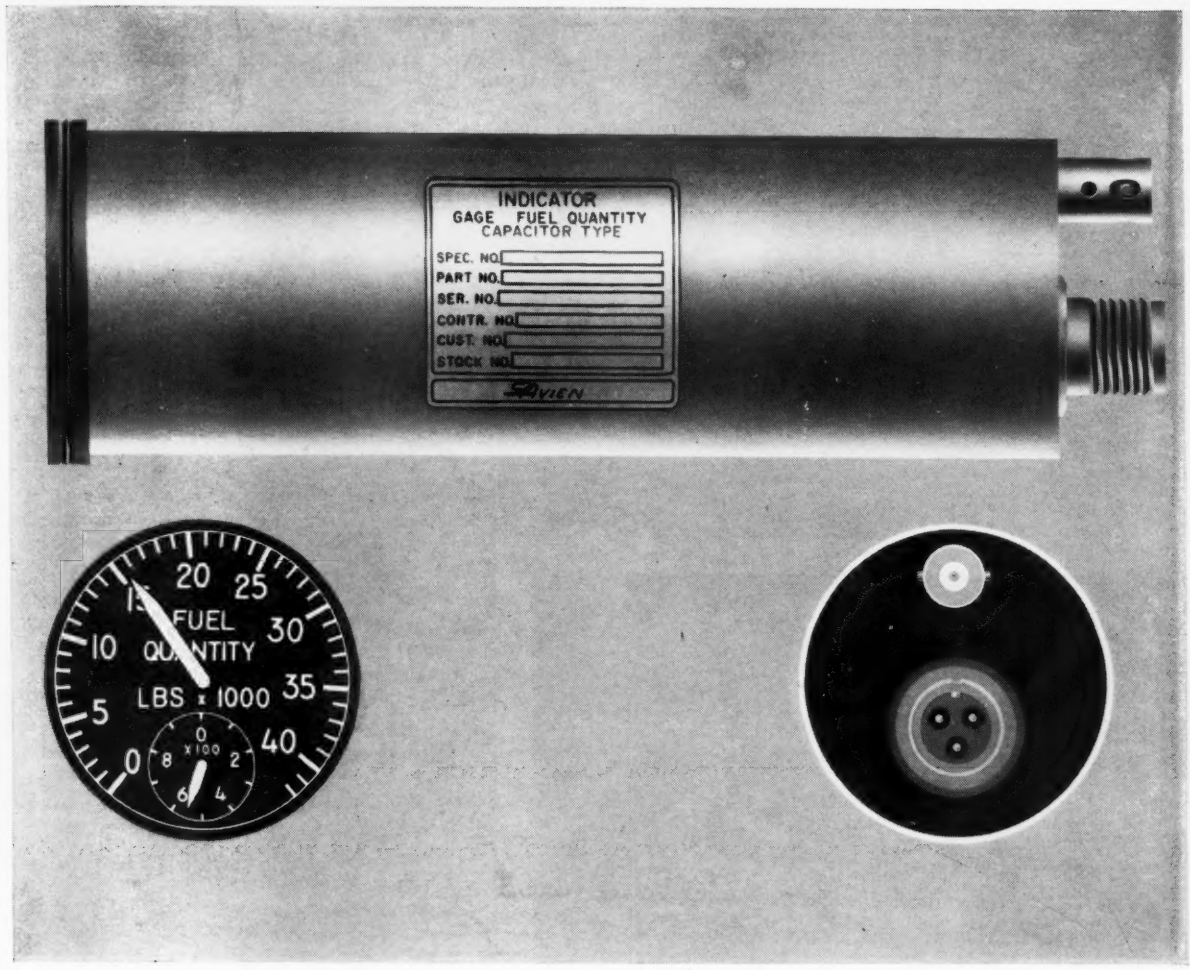
1. *No trained personnel needed.* To err is human, but human fallibility is built *out* of the Two-Unit Gage.

2. *No specialized test equipment needed.* No precision condensers, bridges or calibration boxes required.

3. *No calibration instruction or data needed.* Have you ever run this "paper chase"? By the time you've tracked the information down, it's often obsolete. No more of that!



Fuel gaging progress: Early gaging system (A) had four units. The 1952 system (B) incorporated bridge and amplifier into a single unit, reduced weight almost 15%. Avien's Two-Unit Fuel Gage, now being introduced (C) repackages the system with further miniaturization of components, this time reducing weight by 50%.



Full scale drawing of Avien's Two-Unit Fuel Gage: Front, side and back views of the small-size indicator-amplifier unit. "Plug-in, plug-out" simplicity is the keynote.

Savings all along the line

Simplification means less weight. In the Two-Unit Fuel Gage, the basic system is reduced in weight by 50%.

There are cost savings, too. Less time is spent in installing the Two-Unit Gage. Less wiring and connectors are needed. Less maintenance is required, because there are fewer components to maintain. Trouble-shooting becomes easier, because there are fewer units to cause trouble. And fewer parts must be stocked for replacement and repairs.

Fuel gaging AND fuel management

Avien's Two-Unit system retains an important feature of the former gage. Additional functions for fuel management can be integrated into the basic gage.

This means that simulators, level switches, balancing controls, totalizing equipment, etc., can be hooked up to the basic system – and with even less difficulty.

Another interesting aspect is that the Two-Unit Gage is designed to take advantage of recent improvements in mechanical and electronic design – the new lightweight coaxial cable, the new miniature A N connectors, and Avien's new lightweight tank units.

Now scheduled for production

The Avien Two-Unit Fuel Gage is now available to meet your manufacturing schedules.

The indicator is available in either large or small sizes, with all varieties of dial configurations.

Every month, Avien produces over ten thousand major instrument components for the aviation industry.

We believe that Avien's Two-Unit Gage will contribute to the obsolescence of many earlier systems, including our own.

For further information write or call us.

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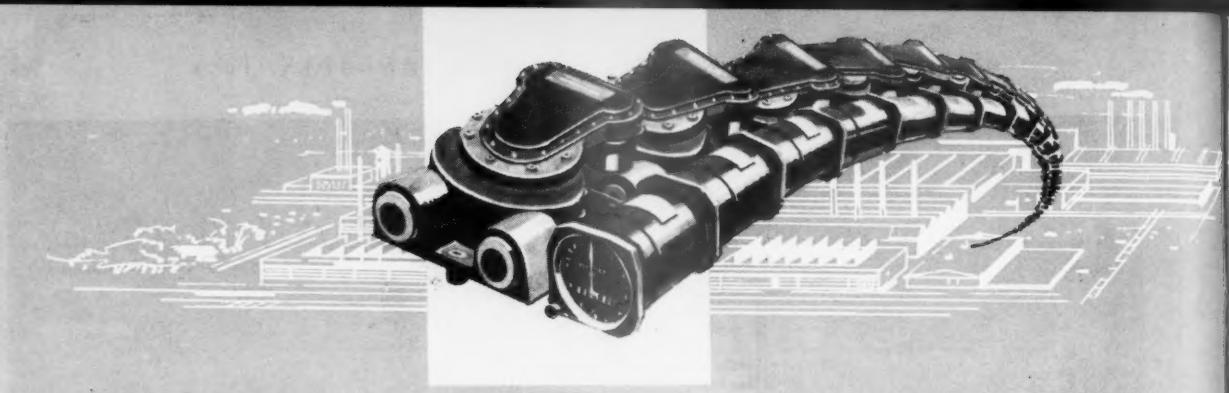

Where Flowmeters Are Concerned...

Eclipse-Pioneer gravimetric fuel flowmeter systems are standard on all military aircraft and on 80% of all commercial planes. There are two solid reasons for this overwhelming preference. First, Eclipse-Pioneer flowmeters measure consumption in terms of pounds—the basic reference of fuel energy. This means the readings on the panel-mounted indicator may be used direct without the necessity of calculating and applying corrections for specific gravity changes as in a volumetric system. Second, the accuracy of Eclipse-Pioneer flowmeters is safeguarded by the most extensive, most precise test facilities in the industry—facilities which include specially-built calibration stands capable of testing flowmeter accuracy *to within 3 ounces per 100 lbs. of fuel.* Eclipse-Pioneer flowmeters are available for single- or multi-engine aircraft . . . reciprocating or jet . . . for on-board consumption or in-flight refueling purposes, and in capacities ranging all the way from 30 P.P.H. to 360,000 P.P.H. Where flowmeters are concerned, Eclipse-Pioneer stands alone. That's because only Eclipse-Pioneer has the quantity and quality of facilities to build the types of flowmeters demanded by the industry.

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Aeronautical Reviews — BOOKS

Book Notes

AERODYNAMICS

Fluid Dynamics. Proceedings of the Fourth Symposium in Applied Mathematics of the American Mathematical Society, University of Maryland, June 22–23, 1951. Cosponsored by U.S. Naval Ordnance Laboratory. M. H. Martin, Editor. (Proceedings of the Symposia in Applied Mathematics, Vol. 4.) New York, McGraw-Hill Book Co., Inc.; Providence, American Mathematical Society, 1953. 186 pp., diagrs. $7.00.

Contents: Some Aspects of the Statistical Theory of Turbulence, S. Chandrasekhar. A Critical Discussion of Similarity Concepts in Isotropic Turbulence, C. C. Lin. The Nonexistence of Transonic Potential Flow, Adolf Busemann. On Waves of Finite Amplitude in Ducts (Abstract), R. E. Meyer. On the Problem of Separation of Supersonic Flow from Curved Profiles, T. Y. Thomas. On the Construction of High-Speed Flows, G. F. Carrier and K. T. Yen. An Example of Transonic Flow for the Tricomi Gas, M. H. Martin and W. R. Thickstun. On Gravity Waves, A. E. Heins. Hydrodynamics and Thermodynamics, S. R. De Groot. Nonuniform Propagation of Plane Shock Waves, J. M. Burgers. Theory of Propellers, Theodore Theodorsen. Numerical Methods in Conformal Mapping, G. Birkhoff, D. M. Young, and E. H. Zarantonello. Flow of Viscous Liquid Through Pipes and Channels, J. L. Synge. The Method of Singularities in the Physical and in the Hodograph Plane, Alexander Weinstein.

Dynamique des Fluides Compressibles; Écoulements Uni et Bi-Dimensionnels (Dynamics of Compressible Fluids; One- and Two-Dimensional Flows). Jean J. Ginoux. Brussels, Centre National d'Études et de Recherches Aéronautiques, 1951. 255 pp., diagrs. In French.

Contents: Part 1, One-Dimensional Flows—Chapter 1, General; Chapter 2, Almost One-Dimensional Constant Motion; Chapter 3, Normal Shock Waves; Chapter 4, Plane Oblique Shock Waves; Chapter 5, Applications of the Theory of One-Dimensional Flows.

Part 2, Two-Dimensional Flows—Chapter 6, General; Chapter 7, The Method of Characteristics; Chapter 8, Applications of the Method of Characteristics; Chapter 9, Development in Series of the Potential Equation, Linearization of the Equations; Chapter 10, The Method of Small Perturbations; Chapter 11, Applications of the Method of Small Perturbations; Chapter 12, Hodograph Methods; Appendixes.

ELECTRONICS

Radio and Radar Technique. A. T. Starr. London, New York, Pitman Publishing Corporation, 1953. 812 pp., figs. $15.

The radio or electronic engineer in search of information is faced with a vast amount of literature that has accumulated from the rapid growth of the science of radio in recent years, especially during and since the war. A large part of this literature is a description of specific applications of ephemeral value. The aim of this book is to cover the essentials of the radio and electronic field in one volume. Emphasis is on methods and physical interpretations, and the work is restricted to methods and techniques only. For this reason no applications are described. Tables of data are not included. The reader is expected to have mastered the subject to a standard of that of a university degree. Emphasis has been placed on the role of noise in electronic systems; techniques in the microwave range; the properties of systems as explicit functions of time—i.e., wave forms; and the fundamental behavior of electronic tubes. The main text is treated in a physical manner, as far as possible, and the mathematical analysis is relegated to appendixes which number 30 and comprise more than one-third of the book. The seven chapters of the text are concerned with reference to communication and physical limits, the electromagnetic medium, microwave and short-wave techniques, antennas, electron tubes, continuous-waveform circuit technique. Fourier methods, analysis of angle modulation and of sampling and quantization, noise, waves, radiation, amplifiers, and networks are some of the subjects covered by the appendixes. The author, who is associated with Standard Telecommunication Laboratories Ltd., has provided extensive bibliographies and excellent author and subject indexes, all of which should make this a valuable work for designers and other advanced workers in the electronic equipment field.

Vacuum-Tube Oscillators. William A. Edson. New York, John Wiley & Sons, Inc., 1953. 476 pp., figs. $7.50.

In this book is presented, from the point of view of design and operation, a systematic and comprehensive treatment of the factors affecting the behavior of vacuum-tube oscillators. The level of the treatment is directed toward the graduate of the usual four-year course in electrical engineering and should also be useful to practicing engineers. The arrangement of the material, together with the subject and name indexes and bibliography of 352 references to more detailed treatments, makes the volume useful also as a reference book. Edson is Visiting Professor, Department of Electrical Engineering, and Research Associate, Electronics Research Laboratory, Stanford University.

Contents: (1) Introduction. (2) Transient Behavior of Linear Systems. (3) Negative Resistance Oscillators. (4) Nonlinear Oscillations. (5) Feedback Systems and Stability Criteria. (6) Resonators. (7) Linear Oscillators. (8) Conventional Harmonic Oscillators. (9) Crystal-Controlled Oscillators. (10) Intermittent Behavior. (11) Operation at High-Power Levels. (12) Practical Relaxation Oscillators. (13) Locking and Synchronization. (14) Frequency Multiplication and Division. (15) Tube and Thermal Noise. (16) Modulation of Oscillators. (17) Automatic Frequency Control. (18) Long-Line and Multiple-Resonance Effects.

For Information on IAS Library Service Facilities, see page 101

Statements and opinions expressed in Book Reviews are to be understood as individual expressions and not necessarily those of the Institute.

FLIGHT SAFETY

Convair 240; Experimental Trials of Emergency Escape with American Airlines, Incorporated. (Aircraft Emergency Evacuation, Report No. 3.) Washington, Office of Aviation Safety, Civil Aeronautics Administration, August, 1952. 31 pp., illus.

Operating Experience and Industrial Trials. (Aircraft Emergency Evacuation, Report No. 2.) Washington, Office of Aviation Safety, Civil Aeronautics Administration, May, 1952. 29 pp., illus.

A Method for Evaluating Devices, Procedures, and Exit Provisions. (Aircraft Emergency Evacuation, Report No. 1.) Washington, Office of Aviation Safety, Civil Aeronautics Administration, April, 1951. 24 pp., illus.

MATERIALS

Oxidation of Metals and Alloys. O. Kubaschewski and B. E. Hopkins. London, Butterworths Scientific Publications; New York, Academic Press Inc., 1953. 239 pp., illus., figs. $6.00.

This book on the oxidation of metals and alloys at elevated temperatures was published after a period that has seen great advances both in the theoretical knowledge of the mechanism of oxidation and in practical applications, of which the development of the gas turbine is an outstanding example. Hitherto, corrosion brought about by metal-liquid reactions, whether by immersion of the metal in aqueous solutions or by its exposure to humid atmospheres, has claimed most attention. In the field of metal-gas reactions, particularly the oxidation of metals at elevated temperatures, data are still widely disseminated in a mass of largely unsifted and uncorrelated literature. In this text the authors, who are Principal Scientific Officers at the National Physical Laboratory, have surveyed and summed up the present position. In the first chapter, the factors that have to be taken into account when dealing with the mechanism of oxidation are considered. Tables are given of relevant thermodynamic and thermal data for the compounds that could form on the surfaces of metals. The second chapter deals with the experimental side of the investigation of oxidation reactions. The third chapter deals with the special theories concerning parabolic and logarithmic oxidation, internal oxidation, the formation of several oxide layers, and the oxidation of binary alloys. In the last chapter, the experimental results relating to the rate of oxidation of the metals and the effects of alloying elements are collected. The book is confined to

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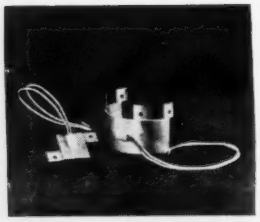

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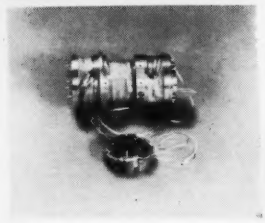

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oxidation of metals and alloys at temperatures of about 100°C. and above. Results obtained at room temperature are occasionally included where they support other results or their principles are of interest. Corrosion in aqueous solutions is not dealt with. The bibliography covers no less than 549 references, and both the author and subject indexes are extensive. The book will be valuable to those who must be concerned with both the theoretical and the production aspects in order to be in a position to apply the results to a particular set of alloys or generally to experimental work in which they may be engaged.

Analysis of Aluminum Alloys; A Compilation of Modern Methods. Edited by G. H. Osborn and W. Stross. New York, Chemical Publishing Co., Inc., 1953. 144 pp., illus., diagrs., figs. $3.50.

This is a survey of analytic methods of which many are new, others are modified versions of known methods, and a few are established standards. Methods range from those requiring modern physicochemical instruments, such as polarographs and photometers, to those that may be carried out with the normal equipment available in a general chemical laboratory. Every method has been thoroughly tested by extensive application in industrial laboratories. Details of procedure have been supplemented, where necessary, by theory. The book lists gravimetric, volumetric, electrolytic, photometric, and polarographic methods for the determination of the most common elements, such as copper, magnesium, silicon, iron, manganese, nickel, zinc, tin, antimony, and chromium. Methods for the determination of less common elements such as beryllium, bismuth, calcium, silver, and sodium are also described.

MATHEMATICS

Contributions to the Theory of Games, Vol. 2. Edited by H. W. Kuhn and A. W. Tucker. (Annals of Mathematical Studies, Vol. 28.) Princeton, N.J., Princeton University Press, 1953. 395 pp., figs. $4.00.

The editing and preparing of this study was done at Princeton University, in the Department of Mathematics, as part of the work of a Logistics Project sponsored by the Office of Naval Research. It contains 21 papers, which have been divided into four groups: Finite Zero-Sum Two-Person Games, Infinite Zero-Sum Two-Person Games, Games in Extensive Form, and General n-Person Games. Eight of the papers presented are published by permission of The RAND Corporation. The continuity of research in this volume with Volume 1 is evidenced by the fact that some of the problems prefaced in the early study are now solved here. Each of the four groups into which the papers have been divided is prefaced by the introduction describing the papers and their interconnections. At the same time, these introductions are designed to indicate how the groups relate to one another. A bibliography supplementary to that published in Volume 1 is included.

Elements of the Theory of Functions. Konrad Knopp. New York, Dover Publications, Inc., 1952. 140 pp., figs. Cloth $2.25; Paper, $1.25.

This textbook by the Professor of Mathematics at the University of Tübingen includes chapters on: Foundations, The System of Complex Numbers and the Gaussian Plane of Numbers, the Riemann Sphere of Numbers, Mapping by Means of Linear Functions, Normal Forms and Particular Linear Mapping, The Logarithm, The Cyclometric Functions, and The Binomial Series.

Lectures on Cauchy's Problem in Linear Partial Differential Equations. Jacques Hadamard. New York, Dover Publications. 316 pp., figs. Cloth, $3.50; Paper, $1.70.

The origin of these investigations is found in the works of Riemann, Kirchhoff, and Volterra. The latter's contributions on spherical and cylindrical waves are particularly basic to this book, since the author has improved and extended

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them so that they are applicable to all (normal) hyperbolic equations instead of only one of them. This edition is a reissue of the 1923 edition published by Yale University Press.

MECHANICS

Proceedings of the First U.S. National Congress of Applied Mechanics. Held at Illinois Institute of Technology, Chicago, Illinois, June 11–16, 1951. New York, American Society of Mechanical Engineers, 1952. 965 pp., illus., diagrs. $20.

This Congress was the first in a sequence of National Congresses that are scheduled to be held at approximately four-year intervals, between the International Congresses of Applied Mechanics. The *Proceedings* contains technical papers that were presented and accepted for publication. The papers, 130 in all, are arranged according to subject matter in four major groups: General Methods, Dynamics, Vibrations, and Impact; Elasticity, Photoelasticity, Plate Theory, and Elastic Instability; Plasticity, Behavior of Materials, and Failure; and Fluid Flow, Aerodynamics, and Heat. In addition to the regular papers, five invited general lectures given at the Congress are included: Some Observations on Elastic Stability, J. N. Goodier. Creep in Metals and Polymers, E. Orowan. Some Topics in the Fundamentals of Fluid Flow Theory, R. von Mises. On the Foundation of High Speed Aerodynamics, Th. von Kármán. Relationship of Heat Transfer to Mechanics and Other Branches of Science, Max Jakob.

METEOROLOGY

Handbook of Statistical Methods in Meteorology. (Gt. Brit., Meteorological Office, M.O. 538.) C. E. P. Brooks and N. Carruthers. New York, British Information Services, 1953. 412 pp., figs. $5.75.

Contents: Part I, Distribution of Observations—(1) Nature of Observation; (2) Probability; (3) One-Dimensional Frequency Distributions; (4) Mean Values; (5) Parameters of Frequency Distributions; Standard Errors and Tests of Significance; (6) Binomial Distribution; (7) Normal Frequency Distribution; (8) Other One-Dimensional (Empirical) Distributions; (9) Analysis of Variance.

Part II, Related Variables—(10) Frequencies of Related Variables, Space Distributions; (11) Distributions of Vector Quantities; (12) Simple Correlation; (13) Partial Correlation; (14) Smoothing and Interpolation; (15) Curve-Fitting.

Part III, Time Series—(16) Persistence; (17) Periodicity, Introduction; (18) Harmonic Analysis; (19) Periodograms Based on Harmonic Analysis; (20) Correlogram and Similar Methods; (21) Selective Methods; (22) Survey of Methods of Analysis; Appendices; Bibliography; Answers to Exercises; Index.

Tornadoes of the United States. Snowden D. Flora. Norman, Okla., University of Oklahoma Press, 1953. 194 pp., illus. $3.50.

This is an account of tornadoes written for the general reader rather than a technical work prepared for meteorologists. The author deals in a comprehensive manner with the frequency and damage of tornadoes, causes, methods of forecasting them, and precautionary measures. He has had 32 years experience as Section Director of the United States Weather Bureau for Kansas and has specialized in summarizing and publishing reports of all tornadoes occurring in that state. All data used, unless otherwise stated, are from official sources.

PHOTOGRAPHY

Test Book of Photogrammetry. M. Zeller. Re-Written and Revised by E. A. Miskin. London, H. K. Lewis & Co., Ltd., 1952. 281 pp., illus., figs. 50*s*.

The present textbook, covering the whole scope of photographic surveying, has its origin in the

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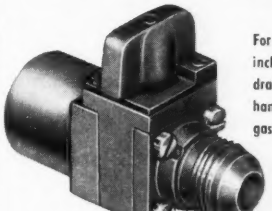
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need for furnishing engineers, surveyors, and students with an adequate presentation of the science of photogrammetry. It aims also to explain to the reader the connection between theory and practice. The essential conditions of the construction of photogrammetric apparatus are stated and some are proved; main types are discussed in detail. The book is divided into four principal parts. The first chapter is concerned with the optic and photographic foundations of photogrammetry. Chapter 2, Terrestrial Photogrammetry, covers general theory, photographic and plotting apparatus, field work and uses including ballistic surveys, close-range photogrammetry, and microphotogrammetry. Chapter 3, on Aerial Photogrammetry, comprises about one half of the book. The principal topics in this section are: photographic apparatus and processes, arrangement of flight charts, stereoscopic plotting, orientation of photographs and their errors, spatial aerial triangulation, and rectification. The final chapter deals with compilation of maps, the mapping of plans for technical purposes, the uses of rectification, cost, and economical aerial triangulation for mapping. The author is Professor of Photogrammetry and President of the Photogrammetric Institute at the Swiss Federal Institute of Technology (ETH), Zurich.

POWER PLANTS

Aircraft Propulsion, Theory and Performance; An Introductory Text Book for Students of Aeronautics. A. W. Morley. London, New York, Longmans, Green & Co., 1953. 221 pp., diagrs., figs. $5.50.

The object of this book is to present in elementary form the basic performance theory of the internal combustion engine as applied to aircraft without going too far into questions relating purely to design. Discussed are the basic principles necessary for an understanding of the operation of the various types of prime mover and the methods used in calculating their power output and thermal efficiency under all conditions of flight. The form of the book arose from a two-year course of lectures to graduate students given by Dr. Morley in the Department of Aircraft Propulsion at the College of Aeronautics, Cranfield. The author treats of the turbojet, propeller-turbine and piston engines. Two chapters, on the ram jet and rocket motor, are contributed by A. B. P. Beeton of the Royal Aircraft Establishment, Farnborough. To his work the author has appended a short bibliography, tables of the standard atmosphere below 100,000 feet, and a brief subject index.

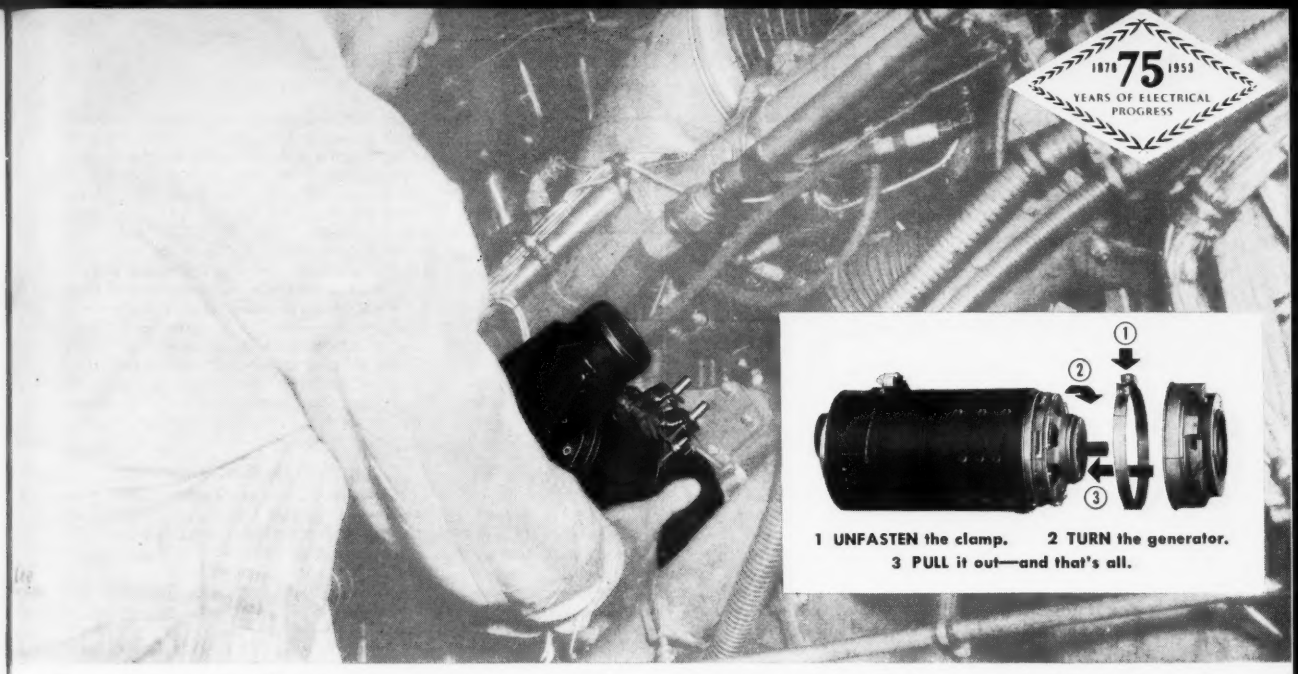
Rocket Propulsion; With an Introduction to the Idea of Interplanetary Travel. Eric Burgess. London, Chapman & Hall, Ltd.; New York, The Macmillan Company, 1952. 235 pp., illus., diagrs. $4.50.

In this work the author has provided a link between nontechnical and popular publications on rocket propulsion and highly technical papers and books. Following an explanation of the general principles of rocket propulsion, there are discussions of fuel and its uses in rocket motors. The problems of fuel feed, fuel tanks, and the control of flight are then treated. Long-range rocket projectiles, interplanetary travel, and atomic energy are the subjects of the closing chapters. There are four appendixes: Laws of Rocket Motion and Efficiencies, Expansion Nozzles and Rocket Motor Thermal Efficiencies Extra-Terrestrial Missiles, and a Brief History of the Rocket and Interplanetary Movement in Great Britain.

PRODUCTION

Engineering Manufacturing Methods. Gilbert S. Schaller. New York, McGraw-Hill Book Company, Inc., 1953. 613 pp., figs. $7.00.

This text is intended to provide a survey of engineering manufacturing methods in a manner that will afford the student some insight into their potentialities. The content has evolved from the author's teaching material, modified by



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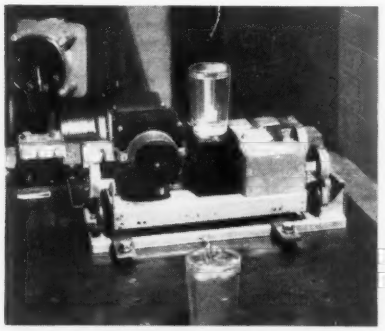

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his experience in engineering industry. Light metals are given attention commensurate with their increasing importance. Foundry subjects are approached from the point of view of the production of economical quality castings. The chapters on welding include all the important features of this process. Emphasis in the treatment of machining is placed on fundamentals with special attention to those machine tools and methods that are widely used. One feature of the book is a list of motion pictures and filmstrips that can be used to supplement the material presented in the book. The author is Professor of Mechanical Engineering, University of Washington.

Contents: (1) Engineered Manufacturing. (2) Materials in Manufacturing. (3) Patterns for Metal Castings. (4) Sands for the Foundry. (5) Gating and Risering Metal Castings. (6) Sand Casting. (7) Sandless Casting Methods. (8) The Melt Shop. (9) Methods of Cleaning Castings. (10) Cold Shaping. (11) Hot Shaping. (12) Heat-Treating. (13) Turning Lathes. (14) Turret Lathes. (15) Automatic Lathes, Chucking Machines, and Screw Machines. (16) Screw Threads. (17) Boring. (18) Planing, Shaping, and Slotting. (19) Milling. (20) Broaching. (21) Drilling. (22) Grinding and Finishes. (23) Gearing. (24) Transfer and Special Machines. (25) Cutting Elements for Machine Tools. (26) Measuring. (27) Welding Basics. (28) Arc Welding. (29) Gas Welding. (30) Brazing and Braze Welding. (31) Resistance Welding. (32) Automatic and Specialized Welding Arcs. (33) Auxiliary Torch and Arc Applications.

Automation; the Advent of the Automatic Factory. John Diebold. New York, D. Van Nostrand Company, Inc., 1952. 181 pp. $3.00.

The word automation as used by the author denotes both automatic operation and the process of making things automatic. In the latter sense it includes several areas of industrial activity such as product and process redesign, the theory of communication and control, and the design of machinery. The connotation intended is delineation of these otherwise loosely related studies as being a distinct area of industrial endeavor. This book is primarily an essay on business problems of automation and indicates the manner in which technological developments can be useful to the businessman. It points out the obstacles that must be confronted and discusses the economic and social effects of automation as a new technology. The starting point of the book was the project carried on by the research group on Automatic Control Mechanisms at the Harvard Business School. The author is associated with the management consulting firm of Griffenhagen and Associates of Chicago.

Contents: Chapter 1, The Problem of Automation; Chapter 2, Control and the Computer; Chapter 3, The Redesign of Product and Process; Chapter 4, Making Machines Automatic; Chapter 5, Automatic Handling of Information; Chapter 6, What Will Automation Mean to Business?; Chapter 7, Some Social and Economic Effects of Automation.

A Manual of Engineering Drawing for Students and Draftsmen. Thomas E. French and Charles J. Vierck. 8th Ed. New York, McGraw-Hill Book Company, Inc., 1953. 715 pp., illus., diagrs. $8.00.

In this new edition the chapter arrangement has been changed, and several new geometric methods have been added to the chapter on applied geometry. There are an almost wholly new chapter on orthographic reading; a new treatment of keys, rivets, and springs; and new material on welding which conforms to the latest ASA standard. The material on screw threads and fasteners now conforms to the new unified thread standards, new Acme and stub Acme standards, and new ASA bolt and screw standards.

ROTATING-WING AIRCRAFT

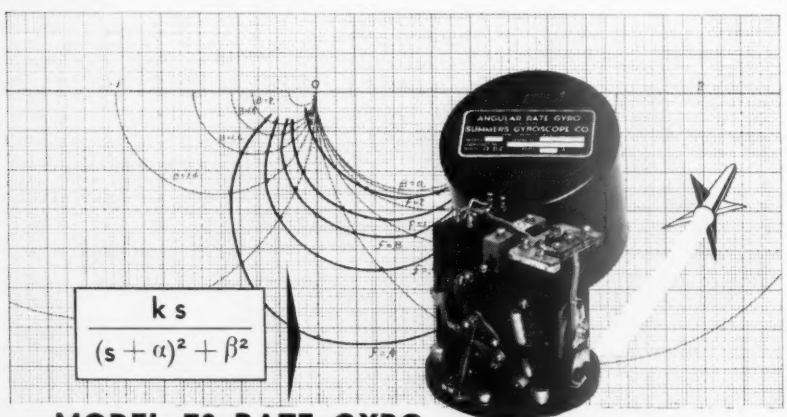
Proceedings of the 9th Annual Forum of the American Helicopter Society, Inc., Washington, May 14–17, 1953. New York, American Helicopter Society, Inc., 1953. 276 pp., illus., diagrs., figs. $7.50 (A.H.S. members $4.50).

Contents: Basic Problems in Helicopter Development, F. L. Doblhoff. Application of Statistical Techniques to the Interpretation of Fatigue Data, D. L. Henry. The Application of Models to Helicopter Vibration and Flutter Research, G. W. Brooks. Applications of Stress Models to Rotor Blade Design Analysis, T. H. Purcell. An Approach to the Determination of Higher Harmonic Rotor Blade Stresses, H. Daughaday and J. Kline. Tip-Mounted Turbojet Engines for Helicopter Rotor Propulsion, J. B. Nichols. Development of the Double Cage Full Phasing Borg-Warner Sprag Clutch, H. P. Troendly, and R. R. Anderson. A Pressed Steel Rotor Hub, Stephen duPont. Simulated Service Testing of Rotor Blades, E. T. Ireton, Jr. Convertiplane Development Tests, W. E. Cobey. Some Problems of Helicopter Rotor Blade Ice Removal, L. C. Houser. The Design of an Electrical Cyclic Thermal De-Icing System for Helicopter Rotor Blades, W. J. Carter. Anti-Ice Testing of the Prewitt Metal Rotor Blade, R. M. DeWitt. A New Approach to Helicopter Stability, F. A. Erickson and George Spratt. Flight Training Panel, I. B. Washburn, G. P. Gaffney, and E. J. Larkin. Flight Characteristics of the Coaxial Helicopter, James V. Ryan.

STRUCTURES

Proceedings of the Society for Experimental Stress Analysis, Vol. 10, No. 2, 1952. Edited by C. V. Mahlmann and W. M. Murray. Cambridge, Mass., Society for Experimental Stress Analysis, 1953. 195 pp., illus., diagrs., figs. $6.00.

Contents: The SR-4 Type Equilateral Flexmeter, G. A. Brewer. Determination of Centrifugal Stresses in a Turbosupercharger Impeller by Means of Stresscoat, W. G. Schmittner. Application of Optical Interference to the Study of Residual Surface Stresses, H. R. Letner. Strength-Stress Life of Helical Gear Teeth, E. J. Wellauer. Full Scale Testing of Trailer Structures, P. J. Jung. Experimental Determination of Foundation Modulus of Elastically Supported Bars and Rings, E. Wenk, Jr. Further Results on the Tuned Test Mass Method of Vibration Testing, S. J. Loring. Hydrodynamic Pressures on Dams Due to Horizontal Earthquakes, C. N. Zangar. A Method of Evaluating Loose-Blade Mounting as a Means of Suppressing Turbine and Compressor Blade Vibration, M. P. Hanson, A. J. Meyer, Jr., and S. S. Manson. Application of Xenon Flashtube to Scattered Light Polariscope, P. L. Balise. Instrumentation and Fundamental Experiments in Plasticity, D. C. Drucker and F. D. Stockton. A Dual-Amplitude Axial-Load Fatigue Machine, A. E. McPherson. The Effect of Superposition of Stress Raisers on Members Subjected to Static or Repeated Loads, A. Q. Mowbray, Jr. The Behavior of SR-4 Wire Resistance Strain Gages on Certain Materials in the Presence of Hydrostatic Pressure, W. R. Clough, M. E. Shank and M. Zaid. Cumulative Index (Vol. 1, No. 1, through Vol. 10, No. 2).



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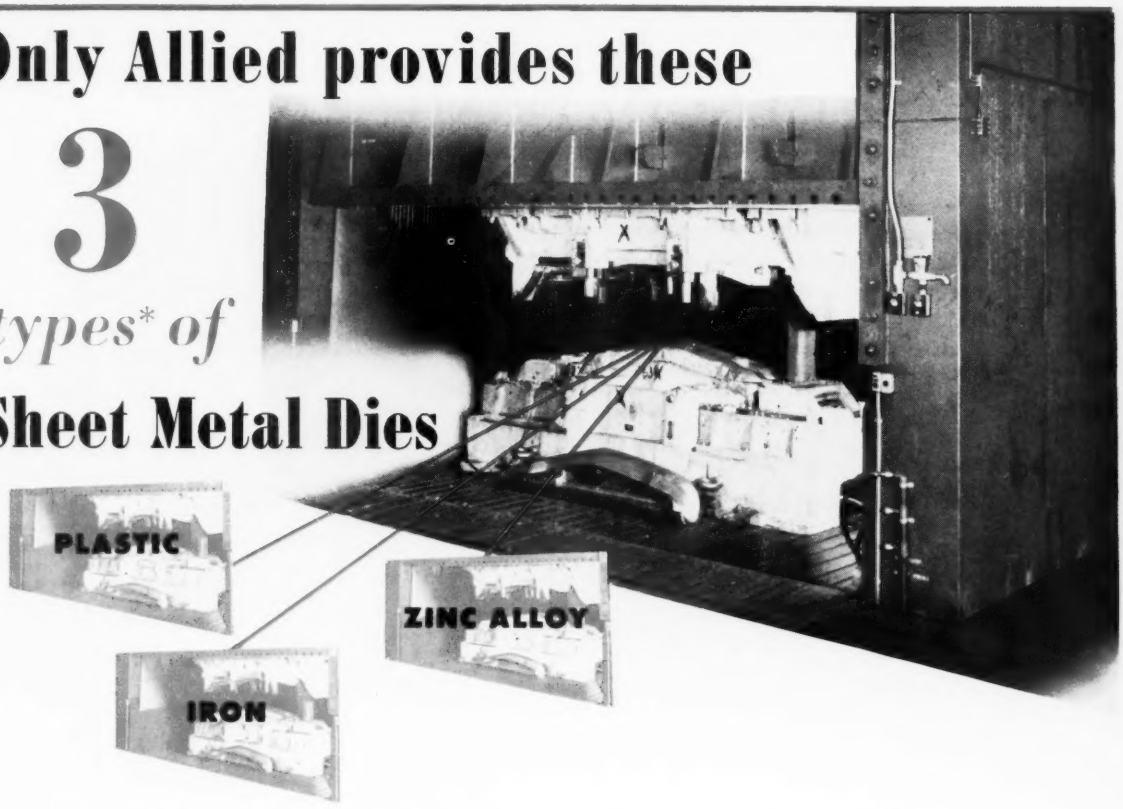

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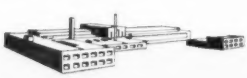

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Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Aeronautical Engineer—To teach aerodynamics, airplane design, and applied mechanics. Should have M.S. degree and some industrial experience. Salary in rank according to qualifications. Write Department of Mechanical Engineering, Oregon State College, Corvallis, Ore.

Professors—Professor Sydney Goldstein, Dean of the Aeronautical Engineering Department of the Israel Institute of Technology in Haifa, Israel, announces openings for two professorships at the Institute: one in the field of aircraft structures; the other in aircraft propulsion or applied aerodynamics. Applicants should have first-rate professional and academic qualifications, be willing to integrate themselves into the life of the country, and, in due course, be able to teach in Hebrew. Applications with full details should be sent, for transmission to Haifa, to the American Technion Society, 1000 Fifth Ave., New York 28, N.Y.

Engineers—Opportunities for employment exist in the Bureau of Aeronautics, Department of the Navy, Washington, D.C. **Electronic Engineer (Radio)**—GS-12, $7,040 per annum. Plan, initiate, and supervise research, design, development, and tests, and recommend engineering action concerning landing aids for naval aircraft. Requirements: 3½ years of professional engineering experience in addition to degree. **Aeronautical Power Plant Research Engineer**—GS-12, $7,040 per annum. Development of general designs and studies of reciprocating, turbojet, turboprop, ram- and pulse-jet, and rocket engines to be used in subsonic and supersonic land and carrier-based aircraft and guided missiles. Requirements: 3½ years of professional engineering experience in addition to degree. **Mechanical Engineer**—GS-12, $7,040 per annum. Responsible for conducting investigations, studies, and projects in gas dynamics. Serves as expert, specialist, and consultant on gas dynamics for the purpose of guiding the development of new naval aircraft power plants. Plans, initiates, and supervises research, design, development, and tests of landing aids. Participates in review and evaluation of design studies made by contractors. Prepares test, installation, performance, and detailed specifications for landing aids and systems. Requirements: 3½ years of professional engineering experience in addition to degree. **Electronic Engineer (Radio)**—GS-12, $7,040 per annum. Interpret present and future military requirements for antisubmarine air-borne radar systems. Analyze existing fleet equipment of this type to determine what improvements can be made to improve their efficiency for meeting operational requirements. Coordinate the research and development programs with other interested services, bureaus, and agencies. Requirements: 3½ years of professional engineering experience in addition to degree. **Aircraft Stability Control Engineer**—GS-12, $7,040 per annum. Plans, initiates, and coordinates guided-missile flight research and flight-research and flight-evaluation programs. Directs and carries out evaluations of the stability and control characteristics of proposed new guided missiles. Prepares specifications pertaining to aerodynamics analyses, especially stability and control of guided missiles. Requirements: 3½ years of professional engineering experience in addition to degree. **Aeronautical Development Engineer (Hydrodynamics)**—GS-11, $5,940 per annum. Under general supervision performs highly specialized aeronautical engineering work in the field of hydrodynamics in connection with design of naval aircraft; assists in model and full-scale research and development projects in hydrodynamics for improvement of seaplane operation. Requirements: 2½ years of professional engineering experience in addition to degree. **Natural Gas Engineer**—GS-11, $5,940 per annum. Devising or examining and approving containers for the storage and transportation of helium. Experience in pressurization and compression systems; knowledge of methods and devices for controlling gases under pressure. Requirements: 2½ years of professional engineering experience in addition to degree. **Mechanical Engineer**—GS-9, $5,060 per annum. Prepares studies and layouts of test facilities for experimental and operational catapults and associated equipment for development of new systems and improvement of existing equipment; prepare preliminary analytical studies of catapulting systems and associated components for launching piloted aircraft to determine theoretical performance characteristics, strength requirements, and optimum configuration. Requirements: 1¼ years of professional engineering experience in addition to degree. **Mechanical Engineer**—GS-9, $5,060 per annum. Prepares preliminary studies to determine the theoretical performance characteristics, strength requirements, and configuration of experimental catapults and associated components. Evaluates design proposals submitted by contractors and Government activities in connection with catapulting equipment to determine conformance with accepted engineering practice. Requirements: 1¼ years of professional engineering experience in addition to degree. **Aircraft Structural Development Engineer**—GS-9, $5,060 per annum. Critical review and analysis of contractor stress calculations consisting of detailed analytical determination of stress tolerances for specific load-carrying structural members. Specification of usable materials for contractor design. Requirements: 1¼ years of professional engineering experience in addition to degree. Applications may be submitted on Standard Form 57, Application for Federal Employment, to the Department of the Navy, Bureau of Aeronautics, Personnel Division, Attention: PE-202, Washington 25, D.C. Standard Form 57 is available at U.S. Post Offices, or may be obtained by writing to the Personnel Division, Bureau of Aeronautics. Visitors to the Washington area may call at Room 3909 of the Main Navy Building, 19th and Constitution Ave., N.W., Washington, D.C.

Engineers, Technologists, Physicists, Physiologists, Metallurgists—The Naval Air Material Center located in the U.S. Naval Base at the extreme south end of Broad Street in Philadelphia, Pa., has vacancies in the above positions for qualified eligibles. These vacancies are at grade GS-5 to GS-12 level with salary ranging from $3,410 to $7,040 per annum. The Naval Air Material Center (the Air Center is divided into three major branches: the Naval Aircraft Factory, the Naval Air Experimental Station, and the Naval Auxiliary Air Station) is engaged on research (applied), development, manufacture, modification, test evaluation, and overhaul of aircraft, aircraft components, and aeronautical materials, including launching and arresting devices. This activity has the job of finding the answers to a never-ending series of problems involving the whole field of aeronautical sciences. Interested persons should file an Application for Federal Employment, Standard Form 57, with the Industrial Relations Department, Naval Air Material Center, Naval Base, Philadelphia 12, Pa. Applications may be obtained from the Industrial Relations Department, Naval Air Material Center, or at any first- or second-class Post Office or from any Civil Service Regional Office.

486. Design Engineer—An outstanding opportunity is offered in a developmental program by a West Coast company. Applicant should have several years of generalized experience and should have some aerodynamic, as well as structural design, experience. The requirements of the work will involve follow-through from the design to the completed article and supervision of its testing. The applicant should be original in his thinking, preferably with one or more patent applications to his credit. This company, which has 250 employees, presents the advantages inherent in a smaller company for a person to have his abilities recognized by the head of the company, plus the opportunity of more rapid advancement as the company grows.

483. Instructor or Professor—Aeronautical Engineering Department of a large Midwestern University has a position open in its teaching and research staff. Prefers American citizen with Ph.D. degree and some industrial experience to teach aircraft design, structural and stress analysis and related subjects. Salary and rank depend upon background. Excellent town in which to live. Growing school and department, desires also to expand its research.

482. Assistant or Associate Professor of Aeronautical Engineering—Wanted by engineering college in Philadelphia to teach undergraduate and graduate courses in aerodynamics, aircraft structures, etc. Opportunity for part-time research or consulting practice. In applying, give details of education and experience, also include photograph.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Available

490. Pilot Engineer—B.S. Aeronautical Engineering. Currently employed as Captain for scheduled air line, covering domestic and international routes; 4,500 hours—air line, light plane, and military fighter. Desires responsible position utilizing flight experience with engineering background. Résumé upon request. Age 29, married.

489. Aerodynamicist—Thermodynamicist—Physicist—Graduate M.E. Seven years' experience in supersonic wind-tunnel testing, aero-

dynamics, and heat transfer. Desires position in supersonic aerodynamic research and development.

488. Pilot—Commercial with all ratings. Qualified DC-3, DC-4, and DC-6 with major airline experience as copilot and flight engineer. Total pilot time 2,700 hours. Total flight engineer time 3,000 hours on DC-6 and B-29. Ground-school instructor ratings in navigation, meteorology, aircraft, aircraft engines, and radio navigation. B.S.Aero.E. degree, age 30. Will relocate.

487. Engineer—B.M.E. and M.S. in Applied Mechanics. Age 30. Nine years' experience in research, development, and design in aircraft and missile fields. Includes airflow research in all speed régimes, using various types of equipment; design of mechanical and electronic equipment and instrumentation associated with experimental research and development facilities; and studies of stability, control, and performance problems on aircraft and missiles. Extensive experience with large wind tunnels. Good background in fundamentals of thermodynamics, mechanics, and flows. Supervisory and administrative experience. Desires responsible position in applied research in aeronautical or related field.

485. Representative or Government Contract Administrator—B.A. and M.B.A. degrees. Fourteen years' aviation experience. Sales and Service Manager prominent aircraft and engine manufacturers. Civilian buyer, Air Force Equipment, Wright Field. World War II production officer, AF Factory Representative, and test pilot. Desires association with aviation division of commercial equipment firm. Opportunity important. Current salary $8,300. Brochure available.

484. Sales Engineer—Seven years' sales and service experience with aircraft components and systems; mechanical and electrical devices to metal and allied industries. Presently employed by leading aircraft equipment company, servicing eastern and middle U.S. air-frame and Government agencies. Married veteran, recently relocated to East Coast.

481. Advertising and Public Relations Manager—B.S. in Engineering and Business Administration, MBA in Marketing. Age 33. Ten years' progressive experience in all phases of industrial promotion: program planning; budgeting and administration; agency and media liaison; space and promotional copy planning, writing, and editing; pamphlets and brochures; and technical publicity. Press, industry, and Government relations. Licensed pilot, mechanic, and radio operator with background in aviation equipment, radio and electronics, and air transport. Desires position offering greater responsibilities and opportunity for advancement.

480. Aeronautical Engineer—S.M.; age 30. Registered Professional Engineer. At present Associate Professor and Head of Aeronautical Engineering Option at small college. Desires position of progressive responsibility either in education or in industry. Location and salary open.

479. Aeromechanical Engineer—B.M.E.; age 34. Broad background in the aircraft industry including guided-missile electromechanical systems development, flight-test research, and stress analysis. Currently engaged as assistant project electromechanical engineer. Accomplishments include direction of missile electrical system design, booster rocket installation design, test equipment design, environmental test program, and flight-test programs. Seeking responsible position in missile, aircraft, or allied fields in greater New York City area only. Current salary, over $7,000. Résumé furnished on request.

478. Aeronautical Engineer—B.Sc. (Hon.); 19 years' experience in the industry. Ten years' experience in aircraft accident investigation and prevention work, in which capacity at present is Head of the Branch in another country. Remainder of experience consists of lecturing in aeronautical subjects and aircraft stressing. Also practical experience of measuring aircraft performance when operating from high-altitude airfields and under high ground-surface temperature conditions. Will be available in the United States in August, 1953, and desires position with aircraft design firm or aeronautical college. Details of experience and requisite documents to meet security regulations sent on request.

477. Aeronautical Engineer—Degree of Aeronautical Engineer; age 33. Twelve years' experience in various fields of engineering. Six years in aerodynamics, aircraft design, maintenance, and manufacturing with three leading air-frame builders and USAF. Six years in plant management, operation, engineering, etc., with a major aircraft company and the textile industry. At present, Project Engineer in Plant Engineering. Desires a staff and management position with responsible company in, or related to, the aircraft industry, with salary level over $8,000. Detailed professional history sent on receipt of letter describing specific position.

476. Aeronautical Engineer—Age 43. Desires to represent responsible companies having, and/or seeking, additional Government contracts with the Air Force, at Dayton, Ohio. Can assure dignified, aggressive, responsible, and complete representation backed by over 20 years of aviation industry experience, including design, flight test, production, executive, and Naval aviation experience at staff level. Just recently released from a tour of active duty with the Navy as Staff Special Projects Officer. Thoroughly familiar with contract negotiation and technical follow-up. List of references, complete résumé furnished upon request.

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other IAS members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th Street, New York 21, N.Y.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

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